APPOLO STUDY CENTRE CHENNAI

APPOLO STUDY CENTRE

ELECTRICITE TAMIL
PART – II
TEST - 8

11thnjhFjp –I	myF - 4	Ntiy› Mwwy kwWk jpwd
12thnjhFjp –I	myF - 1	epiykpddpay
	myF - 2	kpdNdhlltpay

11TH , awgpay;
myF – 4 Ntiy› Mwwy; kwWk; jpwd;
(Work, Energy and Power)

mwpKfk;

mdwhl thotpy Ntiy vdw nrhy gyjuggll jUzqfspy gadgLjjggLfpwJ. ,J cly rhuej Ntiy kwWk kdk rhuej Ntiy Mfpa ,uzilAk FwpfFk. czikapy vej xU nrayghLk nghJthf Ntiy vdNw mioffggLk. Mdhy ,awgpaypy Ntiy vdw nrhy Jyypakhd tiuaiwiaf nfhzLss xU ,ay msthff fUjggLfpwJ. xU nghUspd kJ nraygLjjggll tpir mjid ,lkngaur nrajhy tpirapdhy Ntiy nraaggLfpwJ. Ntiy nratjwfhd jpwd Mwwy vd tiuaWffggLfpwJ. vdNt NtiyAk MwwYk xjj gupkhzjijg ngwWssd. ,awgpaypy MwwyhdJ ,aejpu Mwwy› kpd Mwwy› ntgg Mwwy› mZffU Mwwy Nghdw gyNtW tbtqfspy cssd. gy ,aejpuqfs xU tifahd Mwwiy vLjJfnfhzL NtW tifahd Mwwiy ntspggLjJfpdwd. ,gghlg gFjpapy Kffpakhf ,aejpu Mwwypd ,U tif Mwwyfshd ,aff Mwwy kwWk epiy Mwwy Mfpatwiwf fhzNghk. mLjJ tpthjpffggl ,UggJ› Ntiy nraAk tjk myyJ Mwwy ntspaplggLk tjk MFk. Ntiy nraaggLk tjk jpwd vdggLk. fpufnfl tpisahlby xU rfjpthaej mb vdgJ klilahy geij Ntfkhf mbggijf Fwpffpwj. ,ejg ghlggFjpahdJ Ntiy› Mwwy kwWk jpwd Mfpa %dW ,ay msTfs kwWk mtwwpd KffpajJtk Fwpjj xU eyy Gupjiy tsufFk Nehffjijf nfhzLssJ.

Ntiy (Work)

xU nghUspd kJ nraygLk $\vec{F}$ vdw tpir mjid $\vec{dr}$ vdw ,lgngaurrp VwgLjjp efujJtjhff fUJNthk.

fzpjtpaypdgb› nghUspd kJ tpirapdhy nraaggll Ntiy (W) gpdtUkhW vOjggLfpwJ.

$$W = \vec{F}.\vec{dr}$$

tpiraplhy; nraaggl;l Ntiy

,qF $\vec{F}.d\vec{r}$,d ngUffygyd xU]Nfyu ngUffy myyJ Gsspg ngUffy MFk. ,U ntflufspd]Nfyu ngUffy gyd xU]Nfyu kjpgghFk. (gFjp 2.5.1 lf fhzf). vdNt nraaggll Ntiy xU]Nfyu msthFk. ,J vzkjpgig klLk ngwWssJ kwWk jpirawwJ. SI myF Kiwapy nraaggll Ntiyapd myF Nmmyy J [y (J) MFk. mjd gupkhz thagghL [ML^2T^{-2}] MFk.

$W = F\,dr\cos\theta$

($\vec{a}.\vec{b}$ = abcosqvdgjhy). ,qF qvdgJ nghUspd kJ nraygLjjggll tpirfFk mejgnghUspd ,lngaurrpfFk ,ilNa css Nfhzkhfk.

tpiraplhy nraaggll Ntiy vdgJ tpir ($\vec{F}$) ,lngaurrp ($\vec{dr}$) kwWk mtwwpwfpilNa css Nfhzk qMfpatwiw rhuejJ.

fofzl NeuTfspy nraaggll Ntiy Ropahfk.

(i) tpir Ropahfk; NghJ (F = 0)

cjhuzkhf› cuhatww xU fpiljjsg gugg py khwh jpirNtfjjpy efUk (cuhaT ,yyhjjhy) xUnghUs njhlueJ ,aqfpf nfhzNl ,UfFk. (,J xU ,ylrpa (ideal) #oepiy)

(ii) ,lngaurrp Ropahfk; NghJ (dr = 0)

cjhuzkhf› jplkhf css xU Rtupd kJ tpir nrYjjggllhy tpirahdJ vej ,lngaurrpiaAk VwgLjjhJ.

(iii) tpirAk ,lngaurrpAk xdWfnfhdW nrqFjjhf cssNghJ (q = 90°).

xU nghUshdJ fpiljjsj jpiray efUkNghJ Gtpaug Gtpir (mg) nghUspd kJ Ntiy VJk nraahJ› Vnddpy mJ ,lngaurrpfF nrqFjjhf nraygLfpwJ.

tll ,affjjpy css nghUspdkJ nraygLk ikaNehfF tpirahdJ Ntiy VJk nraahJ. Vnddpy mJ vgNghJk ,lngaurrpfF nrqFjjhf cssJ.

nfhLffggll tpir (F) kwWk ,lngaurrp (dr) fF njhFjJssthW mtwwpwfpilNa css Nfhzk q MdJ nraaggll Ntiyapd kjpgig KbT nrafpwJ.

tpiraplhy nraaggLk vjpufFwp NtiyfF gy cjhuzqfs cssd. fhygeJ tpisahlby› tuu (Goalkeeper) mtiu Nehffp tUk geij xU tpiriar nrYjjpg gpbffpwhu. mttpirahdJ gejpd ,affjjpwF vjpujpirapy geJ mtuJ iffspy XaTepiyfF tUk tiu nrYjjggLfpwJ. tpiriar nrYjJk Neujjpy mtu gejpdkJ vjpuNtiy nrafpwhu. ,ejg ghlggFjpapy NkYk gy vjpuNtiyffhd #oepiyfs gwwp fwgNghk.

vLj;Jf;fhl;L

xU nglb 25 N tpiraplhy 15 m ,lngaurrp VwgLkhW ,OffggLfpwJ. tpirfFk ,lngaurrpfFk ,ilNa css Nfhzk 30° vdpy

tpir apdhy nraagglI Ntiyiaf fhzf.

jPT

tpir F = 25 N

, lgngauŕrŋ dr = 15 m

F kwWk dr , ilNa css Nfhzk q = 30° nraagglI Ntiy W = F dr cos q

$$W = 25 \times 15 \times \cos 30^\circ = 25 \times 15 \times \frac{\sqrt{3}}{2}$$

$$W = 324.76\ J$$

Nfhzk; (q) kwWk; Ntiyapd;ik jd;ik		
Nfhzk; (q)	**cosq**	**Ntiy**
q = 0°	1	NeufFwp> ngUkk
0 < q < 90° (FWqNfhzk)	0 < cosq < 1	NeufFwp
q = 90° (nrqNfhzk)	0	Rop
90° < q < 180°	-1 < cosq < 0	vjpufFwp
q = 180°	-1	vjpufFwp> ngUkk

khwh tpirapdhy; nraagglI Ntiy

xU nghUspd kJ F vdw khwh tpir nraygLkNghJ> tpirapdhy dr vdw rpW , lgngaurrpia VwgLjjr nraagglI rpW Ntiy dWffhd njhluG

$$dW = (F\cos q)\,dr$$

njhlff epiy r_i Kjy ,Wjp epiy r_f tiu ,lgngaurrp VwgLjj nraaggLk nkhjj Ntiy>

$$W = \int_{r_i}^{r_f} dW$$

$$W = \int_{r_i}^{r_f} (F\cos q)\,dr = (F\cos q)\int_{r_i}^{r_f} dr$$

$$= (F\cos q)(r_f - r_i)$$

fo css gugG khwhj tpirapdhy nraagglI Ntiyiaf FwpffpwJ.

khwhj tpirapdhy; nraagglI Ntiy

vLjJf;fhl;L

epiwAss xU nghUs 5 m cauj;jpy ,UeJ jiuapy tpOfpwJ. GtpaugG tpirapdhy nghUspdkJ nraagglI Ntiy vdd? (fhwwpd jiliag Gwffzpf fTk. GtpaugG KLffk g = 10 m s⁻² vdf nfhsf).

jiuT

,eNeutpy nghUspd kJ nraygLk tpir fo Nehffpa Gtpaugg tpir $m\vec{g}$ MFk. ,J khwh tpirahFk.

Gtpaugg tpirapdhy nraaggll Ntiy

$$W = \int_{r_1}^{r_f} \vec{F}.d\vec{r}$$

$$W = (\cos\theta \int_{r_1}^{r_f} dr = (mg.\cos\theta)(r_f - r_1)$$

NkYk nghUshdJ gljjpy fhlbAssthW foNehffpa Gtpaugg tpirapd $\vec{F} = m\vec{g}$ jpiraiy efUfpwJ. vdNt> mtwwpwfpilNa css Nfhzk q= 0°, cos0° =1 kwWk ,lgngaurrp $(r_f - r_i)$ = 5 m

$$W=mg(r_f - r_1)$$

$$W = 2 \times f \times 5 = f$$

vdNt nghUspd kJ nraygLk Gtpaugg tpirapdhy nraaggll Ntiy NeufFwp kjpgigg ngWfpwJ.

vLj;Jf;fhl;L

gljjpy fhlbAssthW epiw m = 1kg nfhzl xU nghUs q= 30°rhaTfNfhzk nfhzl 10m esKss cuhatww jsjjpy NkypUeJ foNehffpr rWfFfpwJ. Gtpaugg tpir kwWk nrqFjJ tpirapdhy nghUspd kJ nraaggll Ntiyiaf fzffpLf. Gtpaugg KLffk (g) = 10 ms^{-2} vdf fUJf.

jiuT:

rhaTjjsjjpy nghUs milAk KLffk gsinq vd Keija ghlggFjpapy fzffplLsNshk.

epAlldpd ,uzlhk tpjpggb> rhaTjjsjjpy nghUspdkJ nraygLk tpir F = mg sinq. ,ej tpirahdJ nghUspd ,affk KOtJk khwhJ vdgij mwpaTk.

Gtpaugg tpirapd rhaTjjsjjpd fpiljjsf $wpdhy (mgsin q) nraaggll Ntiy

$$W = \vec{F}.d\vec{r} = Fdr\cos\theta$$

,qF f vdgJ tpir (mg sinq) kwWk nghUs nryYk jpirfFk (dr)

, i lNa css NfhzkhFk. ,eNeutӯ› tӯir (mg sinq) kwWk ,lgngaurrӯ *dr* Mfӯait xNu jӯiraӯy cssd. vdNt f = 0°kwWk cos f =1

$$W = F\,dr = (mg\sin\theta)\,(dr)$$

(dr = rhajsjjӯd esk)

$$W = 1 \times 10 \times \sin(30°) \times 10 = 100 \times \frac{1}{2} = 50J$$

mg cosq vdw $W kwWk nrqFjJ tӯir N Mfӯait nghUs nryYk jӯirfFr nrqFjjhf cssjhy mit vej NtiyAk nraahJ.

vLj;J f;fhl;L

NkyNehffӯ vwӯaggll 2 kg eӯiwAss xU nghUs 5 m caujij mileJ gӯddu jiuaӯy teJ tӯOfӯwJ (fhwWjjiliag Gwffzӯff Tk) vdӯy gӯdtUtdtwiw fzffӯLf.

(a) nghUs 5 m caujij milAkNghJ GtӯaugG tӯirahy nraaggll Ntiy

(b) nghUs kzLk jiuia milAkNghJ GtӯaugG tӯirahy nraaggll Ntiy

(c) GtӯaugG tӯiraӯdhy NkyNehffӯa kwWk foNehffӯa ,affjjӯy nraaggll nkhjjNtiy kwWk Kbtӯd ,awgӯay KffӯajJtjijf Fwӯggӯ Lf.

jӯT

nghUs NkyNehffӯr nryYkNghJ ,lgngaurrӯ NkyNehffӯa jӯiraӯYk nghUsӯd kJ nraygLk GtӯaugG tӯir foNehffӯa jӯiraӯYk nraygLfӯdwd. vdNt ,lgngaurrӯfFk GtӯaugG tӯirfFk ,ilNa css Nfhzk 180° MFk.

(a) Nky Nehffӯa ,affjjӯy GtӯaugG tӯiraӯdhy nraaggll Ntiy

,qF dr = 5 m kwWk F = mg

$$W_{Nky} = F\,dr\cos q = mg\,dr\cos 180^o$$

$$W_{Nky} = 2 \times 10 \times 5 \times (-1) = -100\,joule.$$

$$[\cos 180^o = -1]$$

(b) nghUs foNehffӯ tӯOkNghJ GtӯaugG tӯir kwWk ,lgngaurrӯ ,uzLk xNu jӯiraӯy cssd. ,jd %yk GtӯaugG tӯirfFk ,lgngaurrӯfFk ,ilNa css Nfhzk q = 0° vd mwӯayhk.

$$W_{fo} = F\,dr\cos 0^o$$

$$W_{fo} = 2 \times 10 \times 5 \times (1) = 100\,joule$$

$$[\cos 0^o = 1]$$

(c) nghUspd KO gazjjpd NghJ (NkyNehffpa kwWk fo Nehffpa ,affk) Gtpahgg tpirapdhy nraaggll nkhjj Ntiy

$W_{nkhjjk} = W_{Nky} + W_{fo}$

$= -100J + 100J = 0$

Gtpahgg tpirahdJ nghUspwF vttpj MwwiyAk khwwtpyiy vdgij ,J Fwpffpwg. nghUs NkyNehffp vwpaggLkNghJ Gwffhuzpfshy nghUSfF Mwwy mspffggLfpwJ. nghUs jpUkg teJ jiuapy NkhJkNghJ nghUs ngww MwwyhdJ Gtpggugg pwF khwwggLfpwJ (jiuapDs nryfpwJ)

vLj;Jf;fhl;L:

(a) xU gS J}fFgth 250 kg epiwia 5000 N tpirahy 5 m caujjpwF J}fFfpwhh.

(a) gS J}fFgtuhy nraaggll Ntiy vdd?

(b) Gtpahgg tpirahy nraaggll Ntiy vdd?

(c) nghUspd kJ nraaggll epfu Ntiy vdd?

jhT:

a. gS J}fFgth epiwiaj J}fFkNghJ tpirAk ,lgngahrrpAk xNu jpirapy cssjhy mtwwpwfpilNa css Nfhzk $q = 0°$ vdNt gS J}fFgtuhy nraaggll Ntiy.

$W_{g.J} = F_W h\cos\theta = F_w h(\cos 0°)$

$= 5000 \times 5 \times (1) = 25000\ J = 25\ kJ$

(b)gS J}fFgth epiwiaj J}fFkNghJ Gtpahgg tpir foNehffp nraygLtjhy tpirAk ,lgngahrrpAk vjpnujph jpirapy cssd. vdNt mtwwpwfpilNa css Nfhzk $\theta = 180°$

$W_< = F_g h\cos\theta = mgh(\cos 180°)$

$= 250 \times 10 \times 5(-1)$

$= -12500\ J = -12.5\ kJ$

(c) nghUspd kJ nraaggll epfu Ntiy (nkhjj Ntiy)

$W_{epfuk} = W_{g.J} + W_<$

$= 25\ kJ - 12.5\ kJ = +12.5\ kJ$

khWgLk; tpirapdhy; nraaggl;l Ntiy

khWgLk tpir (F) xdwpd $W xU nghUspd kJ nraygLk NghJ dr vdw rpW ,lgngahrrpia VwgLjj tpirapdhy nraaggll rpW Ntiy (dw) ffhd njhlhG

$dW = (F\cos)\,dr$

($F\cos\theta$ vdgJ Fvdw khWk tpirapd $W MFk)

,qF>F kwWk θMfpait khwpfs MFk. njhlff epiy riKjy ,Wjpepiy rftiu ,lgngahrrp VwgLjj nraaggll nkhjj Ntiy

$$W = \int_{r_i}^{r_f} dW = \int_{r_i}^{r_f} F\cos q\, dr$$

khWgLk tpirapdhy nraaggll Ntiy tiuglk %yk fhzgpffgglLssJ. tiugljjpd fo css gugG khWk tpirapdhy nraaggll Ntiyiaf Fwpffpwg.

vLj;Jf;fhl;L:

njhlffjjpy xatpy c s s xU nghUspd kJ F = kx^2 vdw khWk tpir nraygLfpwJ. nghUshdJ x = 0 m Kjy x = 4m tiu ,lngahrrp mila tpirapdhy nraaggll Ntiyiaf fzffpLf. (khwpy k=1 N m^{-2} vdffUJf)
jhT:
nraaggll Ntiy

$$W = \int_{x_i}^{x_f} F(x)dx = k\int_0^4 x^2\,dx = \frac{64}{3}Nm$$

Mwpy; (ENERGY):
Mwpy vdgJ Ntiy nraAk jpwikNa MFk. mjhtJ› nraaggll Ntiy vdgJ Mwpyp nrayghNl MFk. mjdhy jhd Ntiy kwWk Mwpy ,uzLk xNu ghpkhz jijf nfhzLssd(ML^{2}T^{-2}).
Ntiy Û Mwpy
Mwpyp Kffpakhd mkrk ahnjdpy xU jdpjj mikggpwF midjJ tif Mwpyfspd $Ljy› mjhtJ nkhjj Mwpy vejr nrayghlbYk vttifahd mfkhwwqfs Vwgllhyk khwhky ,UfFk. ,jd nghUshdJ xU tbtpy kiwAk Mwpy kwnwhU tbtpy ntspggLk. ,JNt Mwpy khwh tpjp vdggLk. ,gghlggFjpapy ehk ,aejpu Mwpy gwwp klLk fwgNghk.

,ejpu Mwpy ,U tifggLk.
1. ,aff Mwpy
2. epiy Mwpy

xU nghUs jdJ ,affjjpdhy nfhzLss Mwpy ,aff Mwpy vdggLk. xU nghUs jdJ epiyggghlbdhy nfhzLss Mwpy epiy Mwpy MFk.

Mwpyp SI myfhdJ nraaggll Ntiyapd myNf MFk. mjhtJ N m(myyJ) [y (J). Mwpyp ghpkhzk› nraaggll Ntiyapd ghpkhzNk MFk. mjd ghpkhzk (ML^{2}T^{-2}) MFk. Mwpyp NtW myFfs kwWk mtwwpd SI kjpgGfs mlltiz ,y fhzgpffgglLssd.

Mwpyp; kwpw myFfSf;Fr; rkkhd SI kjpgGfs;:

myF	,izahd [{y; kjpgGfs;
1 Vhf (CGS myF)	10^{-7}J
1 vyfluhd Nthyl (eV)	1.6×10^{-19} J
1 fNyhhp (cal)	4.186 J
1 fpNyhthl kzp (kWh)	3.6×10^{6} J

,af;f Mwpy; (Kinetic Energy):

,aff Mwpy vdgJ xU nghUs mjd ,affjjhy ngwWss MwpyhFk. midjJ ,aqFk nghUlfSk ,aff Mwpiyf nfhzLssd. ,affjjpy c s s xU nghUs Ntiy nratjwfhd jpwikiag ngwpwUfFk. cjhuzkhf› xU Mzpapd kJ xaT epiyapy itffggll xU Rjjpay Mzpia kujjpDs nrYjjhJ. mNjrkak glk fhlbathW mej Rjjpayhy Mzpia mbfFk NghJ mJ Mzpia kujjpDs nrYjJfpwJ. xU nghUs ,aqFkNghJ› ,affjjpwfhf nraaggLk Ntiyapd msthf ,aff Mwpy mstpLggLfpwJ. ,aqFk nghUspd ,affjjpwfhf nraaggll Ntiyapd msT nghUspd epiw kwWk jpirNtfjjpd vz kjpgG Mfpatwiwr rhhejJ. ,affjjpy ,yyhj xU nghUs ,aff Mwpiyf nfhzbUffhJ.

Ntiy - ,af;f Mwpy; Njwpwk;:

NtiyAk MwwYk rkkhdit. ,J ,aff MwwYfFk nghUeJk. ,jid e&gff m eiwAss xU nghUs cuhatww fljjsg guggy xaty ,Uggjhff fUJNthk.

(F) vdw khwh tiraidhy mNj jiraiy (s) vdw ,lgngahrriia VwgLjj nraaggl Ntiy

$$W = Fs$$

khwhj tirffhd rkdghL›

$$F = ma$$

%dwhtJ ,affr rkdghlil ,tthW vOjyhk.

$$v^2 = u^2 + 2as$$

$$a = \frac{v^2 - u^2}{2s}$$

a ,d kjigig rkdghL ,y gujail

$$F = m\left(\frac{v^2 - u^2}{2s}\right)$$

rkdghL› gujail

$$W = m\left(\frac{v^2}{2s}s\right)\left(\frac{u^2}{2s}s\right)$$

$$w = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

,aff MwwYffhd Nfhit:

Nkwfzl rkdghlby $\left(\frac{1}{2}mv^2\right)$ vdgJ (v) jirNtfjjy ,aqFk (m) eiwAss nghUsid ,aff Mwwiyf Fwifk.

$$KE = \frac{1}{2}mv^2$$

nghUsid ,aff Mwwy vgnghOJk NehFwi kjigGilajhFk.
rkdghL kwWk ,y ,UeJ

$$\Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

vdNt $W = \Delta KE$

rkdghL ,y tyJ gffjjy css Nfhit nghUsid ,aff Mwwy khWghL (ΔKE) MFk.

nghUsid kJ tiraidhy nraaggll Ntiy nghUsid ,aff Mwwiy khwWfiwJ vdgij ,J Fwiffiwj. ,JNt Ntiy - ,aff Mwwy Njwwk vdggLk.

Ntiy - ,aff Mwwy NjwwkhdJ fofhzgtwiw czhjJfiwJ.

1. nghUsid kJtiraidhy nraaggll Ntiy NehfFwiahf ,Uejhy mjd ,aff Mwwy mjifhiffiwJ.

2. nghUsid kJ tiraidhy nraaggll Ntiy vjhFwiahf ,Uejhy mjd ,aff Mwwy Fiwfiwj.

3. nghUsid kJ tiraidhy Ntiy VJk nraaggltyiy vdiy mjd ,aff Mwwy khwhJ. ,J› nghUsid eiw khwhj NghJ tiraidhy nghUshdJ khwh Ntfjjiy ,aqfiaJ vdgij Fwiffiwj.

cejk; kwWk; ,af;f Mwwy; ,ilNa cs;s njhlhG:

m epiwAss xU nghUs; vdw jpirNtfjpy ,aqFtjhff fUJNthk. mjd NehNfhlL cejk; $\vec{p}=m\vec{v}$ kwWk mjd ,aff Mwwy›

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\,(\vec{v}.\vec{v})$$

rkdghL ,d gFjp kwWk njhFjpia epiw m My ngUff

$$KE = \frac{1}{2}\frac{m^2(\vec{v}.\vec{v})}{m}$$

$$= \frac{1}{2}\frac{(m\vec{v}).(m\vec{v})}{m} \quad [\vec{p} = m\vec{v}]$$

$$= \frac{1}{2}\frac{\vec{p}.\vec{p}}{m}$$

$$= \frac{p^2}{2m}$$

$$KE = = \frac{p^2}{2m}$$

,qF $|\vec{p}|$ vdgJ cejjjpd vz kjpgghFk. NehNfhlL cejjjpd vz kjpgig ,tthW ngwyhk.

$$|\vec{p}| = p = \sqrt{2m(KE)}$$

,aff Mwwy kwWk epiw nfhLffgglhy cejjjpd vz kjpgig klLNk fzffpl ,aYk. Mdhy cejjjpd jpiriaf fzffpl ,ayhJ vdgij mwpaTk. vnddwhy ,aff Mwwy kwWk epiw Mfpait]Nfyh msTfshFk.

vLj;Jf;fhl;L

2 kg kwWk 4 kg epiw nfhzl ,U nghUsfs 20 kg m s^{-1} vdw rk cejjJld ,aqFfpdwd.

(a) mit rk ,aff Mwwiyg ngwwpUfFkh?

(b) mit rk Ntfjijg ngwwpUfFkh?

jhT:

(a) nghUspd ,aff Mwwy

$$KE = \frac{p^2}{2m}$$

2 kg epiwAss nghUspd ,aff Mwwy

$$KE_1 = \frac{(20)^2}{2 \acute{} 2} = \frac{400}{4} = 100J$$

4 kg epiwAss nghUspd ,aff Mwwy

$$KE_2 = \frac{(20)^2}{2 \acute{} 4} = \frac{400}{8} = 50J$$

KE_1 ¹ KE_2 vd mwpaTk. mjhtJ ,UnghUlfSk rk cejjijg ngwwpUejhYk mtwwpd ,aff Mwwy rkkyy. fdkhd nghUs ,Nyrhd nghUis tpl Fiwthd ,aff Mwwiyg ngwWssJ. Vnddwhy nfhLffgglL cejjjpwF ,aff MwwyhdJ epiwfF vjph tpfpjjpy cssJ.

$(KE \propto \frac{1}{m})$

(b) cejk p = mv vdgjhy ,U nghUl fSk rk Ntfj ij g ngwwpUffhJ.

epi y Mwwy; (Potential Energy):

xU nghUspd epi y Mwwy vdgJ RwWgGwj ij g nghWjJ mjd epi y kwWk mikgigr rhhejJ. Vnddwhy nghUspd kJ nraygLk gyNtW tpirfSk mjd epi y kwWk mikgigr rhhejNj.

(P vdw Gsspapy css xU nghUspd epi y Mwwy vdgJ mgnghUis xU njhlff epiyg Gssp O (njhlff epiy) Kjy Gssp P (,Wjpepiy) tiu khwh jpirNtfjjpy efhjj Gwtpirahy nraaggll Ntiyapd msT vd tiuaWffggLfpwJ). O vdw njhlffg Gsspapy epi y Mwwy Rop vd vLjJf nfhssyhk.

fzpjtpaypd gb› epi y Mwwy

$$U = \int \vec{F}_a . d\vec{r}$$

,qF njhifalbd vyiy (limit) njhlff epiygGssp O Kjy ,Wjp epiygGssp P tiu mikAk.

epi y Mwwy gy tifggLk. xtnthU tifAk xU Fwpggll tpirAld njhlhGilaJ. cjhuzkhf›

1. Gtp<hgG tpirapdhy nghUs ngwWss MwwyhdJ <hgG mOjj Mwwy MFk.

2. RUstpy tpir kwWk ,J Nghdw ,izahd tpirfspdhy ngwggLk MwwyhdJ klPpaOjj Mwwy MFk.

3. epi y kpddpay tpirahy ngwggLk Mwwy kpddOjj Mwwy MFk.

Mwwy khwwh tpirfisg gwwp ghlggFjp NkYk tphthff fhzyhk. jwNghJ ehk <hgG mOjj Mwwy kwWk klPpaOjj Mwwy gwwp tphthf tpthjpffyhk.

GtpgguggpwF mUfpy; epi y Mwwy;

GtpapyUeJ h cauj jpy <hgG mOjj Mwwy (U) vdgJ nghUis jiuapypUeJ h cauj jpwF khwh jpirNtfjjpy nfhzL nryyj Njitahd Ntiyapd msTfFr rkkhFk.

(m) epiwAss xU nghUs jiuapypUeJ h cauj jpwF GtpahgG tpirfF vjpuhf efhjjggLtjhff fUJNthk.

nghUspd kj nraygLk Gtp<hgG tpir $(\vec{F}_g)$ MdJ $\vec{F}_g = -mg\hat{j}$ (tpirahdJ y jpirapy cssjhy myF ntflh $\hat{j}$,qF gadgLjjggLfpwJ). ,qF vjphFwpahdJ tpir nrqFjjhf foNehffp nraygLtijf FwpffpwJ. nghUis KLffk ,dwp (khwh jpirNtfjJld) efhjj› Gtp<hgG tpir $(\vec{F}_g)$ fF rkkhd vz kjpgigAk vjphjpiriaAk nfhzl $\vec{F}_a$ vdw Gwtpir xdW nghUspd kJ nraygLjjgl NtzLk. mjhtJ $(\vec{F}_a = -\vec{F}_g)$,J $\vec{F}_a = +mg\hat{j}$ vdgijf FwpffpwwJ. NehfFwpahdJ nraygLjjggll tpir NkyNehffp nrqFjjhf cssJ vdgijf FwpffpwJ. vdNt nghUs NkyNehffp cahjjggLk NghJ mjd jpirNtfk khwhky ,UfFk. mjdhy mjd ,aff MwwYk khwhJ. 'h' cauj jpy <hgG mOjj Mwwy (U) vdgJ

nghUis jiuapypUeJ (h) caujjpwF nfhzL nryy Njitahd Ntiyapd msthFk.

$$U = \int_0^h \vec{F}_a . d\vec{r} = \int_0^h \left|\vec{F}_a\right| \left|d\vec{r}\right| \cos q$$

,lgngahrrpAk nraygLjjggll tpirAk mNj NkyNehffpa jpirapy cssjhy mtwwpwfpilNa css Nfhzk›θ = 0°. vdNt cos 0° = 1 kwWk $\left|\vec{F}_a\right| = mg, \left|d\vec{r}\right| = dr$

$$U = mg \int_0^h dr$$

$$U = mg[r]_0^h = mgh$$

nghUspy Nrkpffgg lLss epiyahwwyhdJ Gwtpirapdhy nraaggll NehFwpkjpgGss Ntiyapd %yk tiuaWffggLfpwJ vdgij mwpaTk. ,ayghf ,J FwpggJ ahnjdpy Gwtpiriar nraygLjJk mikgG nghUSfF Mwwiy khwWfpwJ kwWk mJ epiyahwwyhfr Nrkpffgg Lfpw J.nghUshdJ h caujjpypUeJ tOejhy Nrkpffgg lLss epiyahwwy ,aff Mwwyhf khwwggLfpwJ.

xU nghUspd kJ Gwtpir nraygLk NghJ mgnghUs vtthW Ropl KLffjJld (khwh jpirNtfjjpy) ,aqFk?
nraygLjjggLk Gwtpirff rhpahf vjphjpirapy kwnwhU tpir nraygllhy ,J rhjjpaNk. mit ,uzLk rkkhd vzkjpgigf nfhzL› xdWfnfhdW vjphjpirapy nraygLtjhy› nghUspd kJ nraygLk epfutpir RopahFk. vdNt nghUshdJ Ropl KLffjJld ,aqFk.
ehk epiyahwwiy tiuaiw nraAkNghJ nghUshdJ Vd khwh jpirNtfjjpy efhjjggl NtzLk? nghUshdJ khwh jpirNtfjjpy efutpyiy vdwhy mJ njhlff kwWk ,Wjp epiyfspy khWgll jpirNtfqfisf nfhzbUffK. Ntiy - ,aff Mwwy Njwwggb Gwtpirahdj $Ljyhf ,aff Mwwiyr nrYjJk. Mdhy ehk epiyahwwiy Gtpahgg tpir› RUstpy tpir kwWk $Yk tpir Nghdw tpirfSfF tiuaWjJsNshk. vdNt nghUis njhlff epiy Kjy ,Wjpepiy tiu efhjjkNghJ Gw mikgG (Gw tpir) vej ,aff MwwiyAk nrYjjf$lhJ.

vLj;Jf;fhl;L:
2 kg epiwAss nghUs jiuapypUeJ 5 m caujjpwFf nfhzL nryyggLfpwJ (g = 10 ms^{-2}) vdpy
(a) nghUspDs Nrkpffgg lLss epiyahwwy ahJ?
(b) ,ej epiyahwwy vqfpUeJ fpiljjJ?
(c) nghUis mej caujjpwF vLjJr nryy vttsT Gwtpir nraygl NtzLk?
(d). nghUshdJ 'h' caujjpwF vLjJr nryyggLk NghJ mjd kJ nraygLk epfu tpir ahJ?
jhT:

a. epiyahwwy U = mgh = 2 × 10 × 5 = 100 J ,qF NehfFwpahdJ nghUspDs Mwwy Nrkpffgg lLss ijf Fwpffpwj.

b. ,ej epiyahwwyhdJ› Gw tpiria nraygLjJk ntspgGw mikggpypUeJ nghUSfF khwwgg lLssJ.

c. nghUis 5 m caujjpwF vLjJr nryy nraygLjjggll Gw tpir MdJ $\left(\vec{F}_a\right)$ MdJ $\vec{F}_a = -\vec{F}_g$

$$\vec{F}_a = -(-mg\hat{j}) = mg\hat{j}$$

$\hat{j}$ MdJ nrqFjjhf NkyNehffj jpiraiy nraygLk xuyF ntflh MFk.

d) epiyahwwypd tiuaiwapy ,UeJ> nghUshdJ khwhj jpirNtfjjpy efhjjggl NtzLk. vdNt> nghUspd kJ nraygLk epfu tpir Rop MFk.

$$\vec{F}_g + \vec{F}_a = 0$$

klrp epiy Mwwy; (Elastic Potential Energy):

xU RUstpy elrpailar nraaggllhy mjDs xU kstpir cUthfpwJ. RUstpyiy elrpfff$ba myyJ mOfff$ba tpiraiapdhy RUstpy ngwWss epiy Mwwy klrp epiy Mwwy vdggLk. ks tpirfF vjpuhfr nraygLjjggll tpiraiapdhy nraaggll Ntiy RUstpyypy klrp epiy Mwwyhfr Nrkpffgg Lfpwj.

xU RUstpy - epiw mikgigf fUJf. fhlbathW cuhatww fpiljjs Nkiraiy m vdw epiw itffgglLssjhf fUJNthk.

,qF x = 0 vdgJ rkepiyg Gsspd MFk. RUstpyypd xU Kid xU jplkhd RthpYk kWKid epiwAlDk ,izffgglLssJ.

RUstpyyhdJ rkepiyapy ,UfFk tiu mjd epiw Mwwy RopahFk. jwNghJ xU Gwtpir $\left(\vec{F}_a\right)$RUstpy epiw kJ nraygLjjgglL tpiraid jpiraiy (x) njhiyT elrpailfpwJ.

RUstpy tpir $\left(\vec{F}_s\right)$vdwioffggLk xU kstpir RUstpypy cUthfp epiwia mjd njhlff epiyfFf nfhzLtu KaYfpwJ. nraygLjjggll tpir kwWk RUstpy tpir Mfpait vzkjppy rkkhfTk vjpnujph jpiraiYk cssd. mjhtJ $\left(\vec{F}_a = -\vec{F}_s\right)$. `f tpjpaid gb> RUstpypy cUthFk kstpir>

$$\vec{F}_s = -k\vec{x}$$

Nkwfzl rkdghlby css vjphfFwpahdJ RUstpytpir vgNghJk ,lngahrrp $\left(\vec{x}\right)$fF vjphjjpiraiy cssJ vdgijf Fwpffpwj kwWk k vdgJ tpir khwyp MFk. vdNt nraygLjjggll tpir $\vec{F}_a = +k\vec{x}$. NehFwpahdJ nraygLjjggll tpir ,lngahrrpaid jpiraiy cssJ vdgijf Fwpffpwj. RUstpy tpir ,lngahrrp $\vec{x}$l rhhejpUggjhy ,J khWk tpirfF xU vLjJffhllhFk. RUstpy dx vdw rpW njhiyTfF elrpailtjhff fUJNthk. RUstpypd kJ nraygLjjggll tpiraiapdhy $\vec{x}$,lngahrrp miltjwF nraaggll Ntiy klrp epiy Mwwyhf Nrkpffgg Lfpwj.

$$U = \int_0^x \vec{F}_a . d\vec{r} = \int_0^x \left|\vec{F}_a\right| \left|d\vec{r}\right| \cos\theta$$

$$= \int_0^x F_a dx \cos\theta$$

nraygLjjggll tpir $\vec{F}_a$ kwWk ,lngahrrp $d\vec{r}$ (mjhtJ ,qF dx) Mfpait xNu jpiraiy cssd. njhlff epiyiar rkepiy myyJ epLepiyahf vLjJfnfhzlhy x=0 vdgJ njhifalbd fo vyiyahf cssJ.

$$U = \int_0^x kx\,dx$$

$$U = k\left[\frac{x^2}{2}\right]_0^x$$

$$U = \frac{1}{2}kx^2$$

njhlffepiy Ropaypiy vdpy epiwahdJ epiy xiKjy xftiu efhjjggllhy klrp epiy Mwwy

$$U = \frac{1}{2}k\left(x_f^2 - x_i^2\right)$$

rkdghL kwWk %yk mwptJ ahnjdpy ellggll RUstpyypd epiy MwwyhdJ tpir khwpyp k kwWk elrp myyJ mKffk xMfpatwiwr rhhejJ.

RUstpyypDs Nrkpffgglslss epiy MwwyhdJ RUstpyYld ,izffgglLss epiwiar rhhejjyy.

RUs; tpy;ypd; tpir - ,lgngahrrp tiuglk;

tpirAk ,lgngahrrpAk F=-kxvdw Nehtpfjj njhlhgpy csshYk kwWk mit vjpnujph jpirapy ,UggjhYk F kwWk x ,ilNa css tiuglkhdJ fhlbAsthW ,uzL kwWk ehdfhtJ fhygFjpapy klLNk mikej Neh Nfhlhf cssJ. ,J F – x tiuglk tiutjd %yk klrp epiy Mwwiy vspjhff fzffplyhk. epoypIggll gugG (KfNfhzk) RUstpy tpirahy nraaggll Ntiy MFk.

$$\text{gugG} = \frac{1}{2}\ (\text{mbggffk})\ (\text{cauk}) = \frac{1}{2}'(x)'(kx)$$

$$= \frac{1}{2}kx^2$$

RUs;tpy;ypd; epiy Mwwy; - ,lgngahrrp tiuglk;

xU mKffggll myyJ ellggll RUstpy jdDs Nrkpffggll epiy Mwwiy mjDld ,izffggll epiwapd ,aff Mwwyhf khwWfpwJ. epiy Mwwy - ,lgngahrrp tiuglkhdJ fhllgglLssJ. cuhatww #oypy> MwwyhdJ mikggpd nkhjj Mwwy khwhjthW ,aff Mwwypy ,UeJ epiy MwwyhfTk kwWk epiy Mwwypy ,UeJ ,aff MwwyhfTk kzLk kzLk khwwkilfpwJ rkepiyapy>

$$\Delta KE = \Delta U$$

vLj;Jf;fhl;L :

xU RUstpyfs A kwWk B apd RUskhwpypfs vdwthW cssd. mit rk tpirfshy elrpailar nraaggllhy vej RUstpyypd kJ mjpf Ntiy nraaggl NtzLk?

jhT:

$$F = k_A x_A = k_B x_B$$

$$x_A = = \frac{F}{k_A}; x_B = \frac{F}{k_B}$$

RUstpyfs kJ nraaggll Ntiy RUstpyfspy epiy Mwwyhf Nrkpffgglfpwj.

$$U_A = \frac{1}{2}k_A x_A^2; U_B = \frac{1}{2}k_B x_B^2$$

$$\frac{U_A}{U_B}=\frac{k_A x_A^{\,2}}{k_B x_B^{\,2}}=\frac{k_A\left(\frac{F}{k_A}\right)^2}{k_B\left(\frac{F}{k_B}\right)^2}=\frac{\frac{1}{k_A}}{\frac{1}{k_B}}$$

$$\frac{U_A}{U_B}=\frac{k_B}{k_A}$$

$k_A > k_B$ FwpggJ $U_B > U_A$ MFk. vdNt A– it tpl B - ,d kJ mjpf Ntiy nraaggl Ntz Lk.

m epiwAss xU nghUs RUstpyYld ,izffgglL› nraygLjjggLk tpirapdhy mJ eLepiyapy ,UeJ 25 cm mstpwF elrpailfpwJ.

a. RUstpy - epiw mikggpy Nrkpffggll epiy Mwwiyf fzffpLf.

b. ,ej elrpapy RUstpy tpirahy nraaggll Ntiy ahJ?

c. RUstpyyhdJ mNj 25 cm mstpwF mKffggllhy Nrkpffggk epiy Mwwy kwWk mKffjjpdNghJ RUstpy tpirahy nraaggll Ntiy Mfpatwiwf fzffpLf. (RUstpy khwpyp k = 0.1 n m^{-1})

jhkT:

RUstpy khwpyp k = 0.1 N m^{-1}

,lngahrrp x = 25 cm = 0.25 m

a. RUstpyypy Nrkpffggll epiy Mwwy

$$U=\frac{1}{2}kx^2=\frac{1}{2}\times 0.1\times (0.25)^2=0.0031J$$

b. RUstpy tpir $\vec{F}$ My nraaggll Ntiy Wskjpgg

$$Ws=\int_0^x \vec{F}_s.d\vec{r}=\int_0^x (-kx\hat{i}).(dx\hat{i})$$

RUstpy $\vec{F}_s$ tpir vjphfFwp xmrrpd jpirapy nraygLfpwJ. mNjrkak elrpahdJ NehfFwp x mrrpd jpirapy nraygLfpwJ.

$$W_s=\int_0^x (-kx)\,dx=-\frac{1}{2}kx^2$$

$$W_s=-\frac{1}{2}\times 0.1\times (0.25)^2=-0.0031J$$

ntspgGw mikgghy nraaggll Ntiyapd %yk epiy Mwwiy tiuaWffyhk. epiy Mwwypy css NehfFwp Mwwyhdj mikggpypUeJ nghUSfF khwwggLtijf Fwpffpwj. Mdhy ,eNehtpy ks tpirahy nraaggll Ntiy vjphfFwp kjpgGilaJ. Vnddwhy kstpirahdJ ,lngahrrpapd jpirfF vjphjjpirapy nraygLfpwJ.

c. mKffjjpd NghJk nghUspy mNj msT epiy Mwwy Nrkpffgglfpwj.

$$U=\frac{1}{2}kx^2=0.0031J$$

mKff ggLk NghJ RUstpy ks tpirahy nraaggll Ntiy

$$W_s = \int_o^x \vec{F}_s . \vec{d}_r = \int_o^x (kx\hat{i}).\left(-dx\hat{i}\right)$$

mKffggLk Nehtpy RUstpy kstpir NehfFwp x mrir Nehffp nraygLfpwJ kwWk ,lgngahrrpahdJ vjphfFwp x mrrpd jpirapy cssJ.

Mwpwy; khwpwh kwWk; Mwpwy; khwWk; tpirfs; (Conservative force and Non conservative force)

Mwpwy; khwpwh tpir (Conservative Force):

xU nghUis efhjJk NghJ tpiraphy myyJ tpirfnfjpuhf nraaggll Ntiy nghUspd njhlff kwWk ,Wjp epiyfis klLk rhheJk› nghUspd njhlff kwWk ,Wjp epiyfSffpilNa nrdw ghijapd ,ayigr rhuhkYk ,Ugppd; mttpir› Mwwy khwwh tpir vdggLk.

Gtpapy A vdw Gsspapy css xU nghUisf fUJNthk. ,jid h caujjpy css B vdw kwnwhU GsspfF %dW ghijfspy vLjJr nryyyhk.

ghij vtthW ,Ugppdk njhlff kwWk ,Wjp epiyfs khwhky ,UfFk tiu GtpahgG tpirfnfjpuhf nraaggll Ntiy khwhJ. ,JNt GtpahgG tpirahdJ Mwwy khwwh tpirahf ,UggjwF fhuzkhFk. Mwwy khwwh tpir epiy Mwwypd vjphfFwp rhaTfF rkkhFk.

xU ghpkhz Nehtpy

$$F_x = \frac{dU}{dx}$$

klrp RUstpy tpir› epiykpddpay tpir› fhejtpir› GtpahgG tpir Nghdwit Mwwy khwwh tpirfSfF cjhuzqfs MFk.

Mwpwy; khwpwh kwWk; Mwpwy; khwWk; tpirfis xggpLjy:

t.vz;	Mwpwy; khwpwh tpirfs;	Mwpwy; khwWk; tpirfs;
1.	nraaggll Ntiy ghijiar rhhejjyy	nraaggll Ntiy ghijiar rhhejJ
2.	xU Rwwpy nraaggll Ntiy Ropahfk	xU Rwwpy nraaggll Ntiy Ropayy
3.	nkhjj Mwwy khwhJ	MwwyhdJ ntgg Mwwy› xsp Mwwyhf ntspggLfpwJ
4.	nraaggll Ntiy KOtJk klfgglf $baJ	nraaggll Ntiy KOtJk klfgglf $baJ myy.
5.	tpirahdJ epiy Mwwypd vjphfFwp rhaTfF rkkhFk	mJ Nghdw njhlhG ,yiy

tpirfnfjpuhf nraaggll Ntiy ,affjjpd jpirNtfjijr rhhejJ.

Mwwy khwwh kwWk Mwwy khwWk tpirfspd gzGfs njhFffgglLssd.

vLj;Jf;fhl;L:
fofzl NehTfspy Gtpahgg tpirapdhy nraaggll Ntiyiaf fzffpLf.

jhT:

tpir $\vec{F} = mg\left(-\hat{j}\right) = -mg\hat{j}$

,lngahrrp ntflh $d\vec{r} = dx\hat{i} + dy\hat{j}$

(,lngahrrp ,U ghpkhzjjpy cssjhy myF ntflhfs $\hat{i}$kwWk $\hat{j}$ gadgLjjggLfpwJ)

(a) ,affkhdJ nrqFjjhf klLk cssjhy> ,lngahrrpapd fpiljjsf$W dx RopahFk. vdNt ghij 1 ,d topNa tpirapdhy nraaggll Ntiy (h njhiytpwF)

$$W_{ghij1} = \int_A^B \vec{F}.d\vec{r} = \int_A^B \left(-mg\hat{j}\right).\left(dy\hat{j}\right)$$

$$= -mg\int_0^h dy = -mgh$$

ghij 2 ,y nraaggll nkhjj Ntiy

$$W_{ghij2} = \int_A^B \vec{F}.d\vec{r} = \int_A^C \vec{F}.d\vec{r} + \int_C^D \vec{F}.d\vec{r} + \int_D^B \vec{F}.d\vec{r}$$

Mdhy

$$\int_A^C \vec{F}.d\vec{r} = \int_A^C \left(-mg\hat{j}\right).\left(dx\hat{i}\right) = 0$$

$$\int_C^D \vec{F}.d\vec{r} = \int_C^D \left(-mg\hat{j}\right).\left(dy\hat{j}\right)$$

$$= mg\int_0^h dy = mgh$$

$$\int_D^B \vec{F}.d\vec{r} = \int_D^B \left(-mg\hat{j}\right).\left(-dx\hat{i}\right) = 0$$

vdNt ghij 2 ,d topNa tpirapdhy nraaggll nkhjj Ntiy

$$W_{ghij2} = \int_A^B \vec{F}.d\vec{r} = -mgh$$

Mwwy khwwh tpirapdhy nraaggll Ntiy ghijiar rhhejjyy vdgij mwpaTk.

vLjJffhlL
2kg epiwAss xU nghUs ,aff cuhaTf Fzfk 0.9 nfhzLss xU guggpy 20 N Gwtpirapdhy 10m njhiytpwF efhjjggLtjhff fUJf. Gwtpir kwWk ,aff cuhatpdhy nraaggll Ntiy vdd? Kbitg gwwpa fUjijf $Wf. ($g = 10\ ms^{-2}$vdf nfhsf)
jhT:

m = 2 kg, d = 10 m, F_{ext} = 20 N, = μ_k = 0.9
xU nghUs fpilkll guggpy ,aqFk NghJ mJ ,U tpirfisg ngWfpwJ.

a. Gw tpir F_{ext} = 20 N

b. ,aff cuhaT tpir

$f_k = \mu_k mg = 0.9 \times (2) \times 10 = 18$ N

Gwtpirapdhy nraaggll Ntiy

$W_{ext} = F_d = 20 \times 10 = 200$ J

,aff cuhaT tpirapdhy nraaggll Ntiy

$W_k = f_k d = (-18) \times 10 = -180$ J

,qF vjphfFwpahdJ ,aff cuhaT tpir› ,lgngahrrpapd jpirfF vjpuhf cssijf Fwpffpwj.

nghUspd kJ nraaggll nkhjj Ntiy

$W_{total} = W_{ext} + W_k = 200 - 180 = 20$ J

cuhaT tpir xU Mwwy khwWk tpir vdgjhy Gwtpirahy nfhLffggll 200 J ,y 190 J ,offgglJ kwWk ,jid klnlLff ,ayhJ.

Mwwy; khwh tpjp (Law of Conservation of energy):

xU nghUis ehk NkyNehffp vwpejhy mjd ,aff Mwwy FiweJ nfhzNl nryfpwJ kwWk mjd epiy Mwwy mjpfhpjJf nfhzNl nryfpwJ (fhwWj jilia Gwffzpffkngh) nghUshdJ ngUk caujij milAkNghJ Mwwy KOtJk epiy MwwyhFk. mJNghdW nghUshdJ ngUk caujjpy ,UeJ tOejhy mjd ,aff Mwwy mjpfhpffFk kwWk epiy Mwwy FiwAk. jiuiaj njhLkNghJ mjd Mwwy KOtJk ,aff MwwyhFk. ,ilggll Gsspfspy Mwwyhdj ,aff MwwyhfTk epiy MwwyhfTk ,UfFk. nghUshdJ jiuia milAk NghJ ,aff

,ej cjhuzjjpy xtnthU Gsspapyk epiyahwwy kwWk ,aff Mwwy khWk. vdpDk› ,aff Mwwy kwWk epiy Mwwypd $Ljy mjhtJ nkhjj ,aejpu Mwwy vgNghJk khwhJ. ,J nkhjj Mwwy khwhJ vdgijf Fwpffpwj. ,JNt Mwwy khwh tpjpahFk.

Mwwy khwh tpjpapdgb Mwwiy MffNth mopffNth ,ayhJ. MwwyhdJ xU tifapypUeJ kwnwhU tifahf khwf$baJ. Mdhy xU jdpjj mikggpd nkhjj Mwwy khwpypahf ,UfFk.

tpsfFtJ ahnjdpy›h caujjpy xatpy css xU nghUspd nkhjj Mwwy KotJk epiy Mwwy (U = mgh) klLNk. NkYk h caujjpy mjd ,aff Mwwy (KE) RopahFk.

nghUs fNo tpOkNghJ 'y' njhiytpy mjd epiyahwwy kwWk ,aff Mwwy RopahfhJ. mNjrkak h caujjpy ,Uej mNj mstpy nkhjj Mwwy khwhky ,UfFk. nghUs jiuiaj njhl neUqFk NghJ epiy Mwwy RopahFk kwWk nkhjj Mwwy ,aff Mwwyhf klLNk ,UfFk.

vLj;Jf;fhl;L

1 kg epiwAss xU nghUs h = 10 m caujjpypUeJ tpOfpwJ.

(a) h = 10 m caujjpy nghUspd nkhjj Mwwy

(b) h = 4 m caujjpy nghUspd epiy Mwwy

(c) h = 4 m caujjpy nghUspd ,aff Mwwy

(d)nghUs jiuapy NkhJk Ntfk Mfpatwiwf fzffpLf.
(g = 10 ms^{-2}vdf nfhsf)

jhT:
(a) Gtpahgg tpir Mwwy khwwh tpirahFk. vdNt ,affk KOtJk nkhjj Mwwy khwhky ,UfFk.

h = 10 m caujjpy nkhjj Mwwy (E) KOtJk epiy Mwwyhf ,UfFk.

E = U = mgh = 1 × 10 × 10 = 100 J

(b) h = 4 m caujjpy epiy Mwwy

U = mgh = 1 × 10 × 4 = 40 J

(c) ,affk KOtJk nkhjj Mwwy khwypy vdgjhy h = 4 m caujjpy ,aff Mwwyhd J

KE = E – U = 100 – 40 = 60J

khwhf 4 m caujjpy nghUspd jpirNtfjjpy ,UeJk ,aff Mwwiyf fhzyhk. 6 m toej gpwF css jpirNtfjij ,affr rkdghlbypUeJ fzffplyhk.

$$v=\sqrt{2gh}=\sqrt{2\acute{}10\acute{}6}=\sqrt{120}\,ms^{-1}$$

$$v^2=120$$

,aff Mwwy $KE=\frac{1}{2}mv^2=\frac{1}{2}\acute{}1\acute{}120=60J$

d. nghUs jiuapy NkhJk epiyapy nkhjj Mwwy KOtJk ,aff MwwyhFk. NkYk epiy Mwwy U = O

$$E = KE = \frac{1}{2}mv^2=100\,J$$

$$v = \sqrt{\frac{2}{m}KE}=\sqrt{\frac{2}{1}\acute{}100}=\sqrt{200}\gg 14.12\,ms^{-1}$$

vLjJf;fhl;L
gljjpy fhlbAssthW 100 kg epiwAss xU nghUs jiuapypUeJ 10 m caujjpwF ,U khWgll topfspy J}ffggLfpwJ. ,U NehTfspYk Gtpahgghy nraaggl Ntiy vdd? rhajsjjpd topahf nghUis vLjJr nrytJ vspjhf cssJ Vd?

jhT:
m = 100 kg, h = 10 m
ghij (1) ,d top Na:
nghUis 10 m caujjpwFj J}ffj Njitahd rpWk tpir F_1 tpir Gtpahgg tpirfFr rkkhf ,Uff Ntz Lk.
F_1 = mg = 100 × 10 = 1000 N
ghij (1) ,d top Na efhej njhiyT h = 10 m
ghij (1) ,d top Na nghUspd kJ nraaggl Ntiy
W = Fh = 1000 × 10 = 10,000 J

ghij (2) ,d top Na:

rhajsjjpd topNa nghUisf nfhzL nryy nghUspd kJ ehk nrYjJk rpWk tpir F_2MdJ mg– fF rkkhf ,yiy› khwhf mg sinθ-fF rkkhFk. mg sinθ< mg)
vdNt (mg sin θ< mg)
rhajsg ghijapd eskhdJ

$$l=\frac{h}{\sin 30^\circ}=\frac{10}{0.5}=20m$$

ghij (2) ,d topNa nghUspd kJ nraaggll
Ntiy W = $F_2 l$ = 500 × 20 = 10,000 J
GtpahgG tpirahdJ Mwwy khwwh tpir vdgjhy Gtpahgghy nghUspd kJ nraaggll Ntiy mjid nfhzL nrdw ghijiar rhhejjyy.

,U ghijfspYk GtpahgG tpirahy nraaggll Ntiy 10›000 J MFk.

ghij (1) ,d topNa: Fiwthd njhiyT efhjj GtpahgGfF vjpuhf mjpfkhd tpir nrYjj NtzbAssJ.

ghij (2) ,d topNa: mjpfkhd njhiyT efhjj GtpahgGfF vjpuhf Fiwthd tpir nrYjj NtzbAssJ.

rhajsjjpd topNa nrYjjggl Ntzba tpir Fiwthf cssjhy rhajsjjpd topahf nghUis vLjJr nrytJ vspjhf cssJ.

vLj;Jf;fhl;L:
m epiwAss xU nghUs jiuapypUeJ $v_0$vdw njhlff NtfjJld VwpaggLfpwJ. h caujjpy mjd Ntfjijf fhzf.

jhT:
GtpahgG tpir Mwwy khwwh tpir vdgjhy ,affk KOtJk nkhjj Mwwy khwhJ.

Mwwy;	njhlf;fj;jpy;	,Wjpapy;
,aff Mwwy	$\frac{1}{2}mv_0^2$	$\frac{1}{2}mv^2$
epiy Mwwy	0	mgh
nkhjj Mwwy	$\frac{1}{2}mv_0^2+0=\frac{1}{2}mv_0^2$	$\frac{1}{2}mv^2+mgh$

h caujjpy epiy Mwwy› ,aff Mwwy kwWk nkhjj Mwwy Mfpatwwpd ,Wjp kjpgGfs fzffplgglLssd.

Mwwy khwh tpjpapd gb njhlff kwWk ,Wjp nkhjj Mwwyfs rkkhFk.

$$\frac{1}{2}mv_0^2=\frac{1}{2}mv^2+mgh$$

$$v_0^2=v^2+2gh$$

$$v=\sqrt{v_0^2-2gh}$$

ghlggFjp ,y ,afftpay rkdghlilg gadgLjjp Ezfzpj Kiwggb ,J Nghdw KbT ngwgglIij ftdpffTk. vdpDk Mwwy khwh tpjpapd Kiwggb fzffpLtJ Ezfzpj Kiwiatpl kpfTk vspjhf cssJ.

xU RUstpyYld ,izffggll 2kg epiwTss xU nghUs mjd rkepiyapypUeJ x = 10 m vdw njhiyTfF efhjjggLfpwJ. RUstpy khwpy k = 1 N m^{-1}kwWk gugG cuhatwwfhff fUJf.

a. nghUshdJ rkepiyiaf flfFkNghJ mjd Ntfk vdd?

b. nghUshdJ rkepiyiaf flfFk NghJk›x = ± 10 m vdw tpskG epiyia flfFk NghJk nghUspd kJ nraygLk tpir ahJ?

jhT:

a. RUstpy tpir xU Mwwy khwwh tpir Mifahy nkhjj Mwwy khwpy MFk. x = 10m vDkNghJ nkhjj Mwwy KOtJk epiy Mwwyhf klLNk ,UfFk.

$$E = U = \frac{1}{2}kx^2 = \frac{1}{2}\acute{}(1)\acute{}(10)^2 = 50J$$

nghUs rkepiyiaf flfFk NghJ (x = 0), epiy MwwyhdJ

$$U = \frac{1}{2}\acute{}1\acute{}(O) = OJ$$

,eepiyapy KO MwwYk ,aff Mwwyhf klLNk cssJ.

$$E = KE = \frac{1}{2}mv^2 = 50J$$

Ntfk

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2\acute{}50}{2}} = \sqrt{50}ms^{-1} \gg 7.07\,ms^{-1}$$

RUstpyypd kstpir F = – kx vdgjhy nghUshdJ eLepiyiaf flfFk NghJ mJ vttpiriaAk czuhJ. eLepiyapy nghUshdJ kpf Ntfkhf efUfpwJ vdgij mwpaTk. nghUshdJ x = +10 m (elrp) vdw epiyapy cssNghJ tpir F = -kx

F = -(1) (10) = - 10N ,qF vjphFwpahdJ tpir eLepiyia Nehffp mjhtJ vjph mrir Nehffp cssijf Fwpffpwj. NkYk nghUshdJ

x = ± 10 m (mKffk) vdw epiyapy cssNghJ mJ czUk tpir

F = -(1) (10) = - 10N ,qF NehfFwpahdJ tpir Neh x - mrir Nehffp cssijf Fwpffpwj.

vdw epiyapy nghUshdJ ,ej ,U tpskG Gspspfspyk ngUk tpiria czhejhYk fzNeu xaT epiyfF tUfpwJ.

nrqFjJ tl;l ,af;fk; (Motion in a vertical circle):

m epiwAss xU nghUs epiwaww› elrpj jdikaww E}ypd xU Kidapy ,izffggLfpwJ. NkYk› E}ypd kWKidahdJ epiyahf ,UfFkhW nghUjjgglLssJ. mejgnghUs nrqFjJj jsjjpy mikej tll ,affjij Nkwnfhstjhff gwwp mwpa jdpjj nghUspd tpirgglk (Free body dagram) xdiwf fUJNthk. ,qF epiyntflh $\left(\vec{r}\right)$ MdJ nrqFjjhd foNehffpa jpirAld Nfhzjij θVwgLjjp gljjpy csthW cldb jpirNtfjijf nfhzLssJ.

1. fo Nehffp nraygLk Gtpahgg tpir
2. E}ypd topNa nraygLk ,Otpir

nghUspd kJ epA+lldpd ,uzlhk tpjpiag gadgLjj› njhLNfhlLj jpirapy›

$$mg\sin\theta = ma_t$$

$$mg\sin\theta = -m\left(\frac{dv}{dt}\right)$$

,qF $a_t = \frac{dv}{dt}$ vdgJ njhLNfhlLj jpirapy vjph KLffk MFk.

Mujjpirapy›

$$T - mg\cos\theta = m a_r$$

$$T - mg\cos\theta = \frac{mv^2}{r}$$

,qF $a_r = \frac{v^2}{r}$ vdgJ ikaNehfF KLffk MFk.

,affjij edF GHpeJ nfhsSktifapy tlljij A, B, C, D vdw ehdF gFjpfshfg gphpffyhk. Nkwfzl ,U rkdghLfspy ,UeJ foffzlthW ehdF Kffpa fUjJfis GhpeJ nfhssyhk.

1. nghUshdJ midjJ θ kjpgGfSfFk (θ= 0° jtpu) njhLNfhlLj jpirapy KLffjij (g sin θ) nfhzbUffpwJ. ,ej nrqFjJ tll ,affk xU ruhd tll ,affk myy vdgJ njspthfpwJ.

2. rkdghLfs kwWk ,UeJ mwpeJ nfhstJ vddntdpy ,affjjpd NghJ jpirNtfjjpd vz kjpgG khWtjhy› E}ypd ,Otpirak khWfpdwJ.

3. rkdghL $T = mg\cos q + \frac{mv^2}{r}$ RlbffhlLtJ tlljjpd A kwWk D gFjpfspy (- $\frac{p}{2} < 0 < \frac{p}{2}$ kwWk cos θNehfFwp) mg cosθvgNghJk Ropiatpl mjpfkhFk. vdNt jpirNtfk RopahdhYk ,Otpir RopahfhJ.

4. rkdghL $\frac{mv^2}{r} = T - mg\cos q$ NkYk RlbffhlLtJ tlljjpd B kwWk C gFjpfspy ($\frac{p}{2} < q < \frac{3p}{2}$ kwWk cos θvjhfFwp)› rkdghlbd ,uzlhtJ gFjp (- mg cos θ) vgNghJk Ropia tpl mjpfkhFk. vdNt ,Otpir RopahdhYk jpirNtfk RopahfhJ.

nrqFjJ tll ,affk njhlhghd fzfFfis jhTfhzkNghJ Nkwfzl fUjJfis kdjpy nfhs Ntzlk.

mbggff Gsspl 1 kwWk Nkwgff Gsspl 2 Mfpa ,U epiyfis klLk fUjjpy nfhzL NkYk gFgghaT nraNthk. nghUspd jpirNtfkhdJ mbggff Gsspl 1 ,y v_1 vdTk. Nkwgff Gsspl 2 ,y v_2 vdTk NtW vej Gsspapyk v vdTk nfhsf. jpirNtfjjpd jpir midjJg Gsspfspyk tllgghijapd njhLNfhlLj jpirapy cssJ. mbggffg Gsspapypl UeJ E}ypd ,OtpirahdJ $\breve{T}_1$ vdTk› Nkwgff Gsspapypl UeJ ,Otpir $\breve{T}_2$ vdTk NtW vej Gsspapyk ,Otpir $\breve{T}$ vdTk nfhsf. xtnthU Gsspapyk ,Otpirikag Gsspia Nehffp nraygLfpwJ. Mwwy khwh tpjpiag gadgLjjp ,ej ,U Gsspfspyk ,Otpirfs kwWk jpirNtfqfis fzffplyhk.

mbggf;f Gs;sp (1):

nghUshdJ mbggff Gssp 1 ,y cssNgh Gtpahgg tpir $\vec{mg}$ nghUspd kJ nrqFjjhf foNehffp nraygLfpwJ kwWk ,Otpir $\vec{T_1}$ nrqFjjhf NkyNehffp mjhtJ ikagGsspia Nehffp nraygLfpwJ. rkdghL ,UeJ ehk ngWtJ

$$T_1 - mg = \frac{mv_1^2}{r}$$

$$T_1 = \frac{mv_1^2}{r} + mg$$

Nkwgf;f Gs;sp (2):

Nkwgff Gssp 2 ,y nghUspd kjhd Gtpahgg tpir $\vec{mg}$ kwWk ,Otpir $\vec{T_2}$ Mfpa ,uzLk foNehffp mjhtJ ikagGsspia Nehffp nraygLfpwJ.

$$T_2 + mg = \frac{mv_2^2}{r}$$

$$T_2 = \frac{m_2^2}{r} - mg$$

rkdghLfs kwWk $T_1 > T_2$ vd mwpayhk. ,Otpiraid NtWghL $T_1 - T_2$ MdJ rkdghL rkdghL ,UeJ fopggjd %yk ngwggLfpwJ.

$$T_1 - T_2 = \frac{mv_1^2}{r} + mg - \left(\frac{mv_2^2}{r} - mg\right)$$

$$= = \frac{mv_1^2}{r} + mg - \frac{mv_2^2}{r} + mg$$

$$T_1 - T_2 = \frac{m}{r}\left(v_1^2 - v_2^2\right) + 2mg$$

Gssp 1 kwWk 2 ,y Mwwy khwh tjpiag gadgLjjp $\left(v_1^2 - v_2^2\right)$ kjpgig vspjhff fzffplyhk.

,Otpirak nghUs nryYk jpirAk vgNghJk xdWfnfhdW nrqFjjhf cssjhy ,Otpirahdj nghUspd kJ vttpj NtiyAk nraahJ. Gtpahgg tpirahdJ nghUspd kJ Ntiy nrafpwJ. NkYk mJ Mwwy khwwh tpir vdgjhy ,affk KOtJk nghUspd nkhjj Mwwy khwhJ.

Gssp 1 ,y css nkhjj Mwwy (E_1) Gssp 2 ,y css nkhjj Mwwy (E_2) fF rkkhFk.

$E_1 = E_2$

Gssp 1 ,y epiy Mwwy $U_1 = 0$ (Gssp 1 I FwpgGg Gsspahf vLjJfnfhstjd %yk)

Gssp 1 ,y ,aff Mwwy $KE_1 = \frac{1}{2}mv_1^2$

Gssp 1 ,y nkhjj Mwwy $E_1 = U_1 + KE_1 = 0 + \frac{1}{2}mv_1^2 = \frac{1}{2}mv_1^2$

,JNghdNw Gssp 2 ,y epiy Mwwy $U_2 = mg\,(2r)$
(Gssp 1 ,y ,UeJ hkjpgG 2r MFk)

Gssp 2 ,y ,aff Mwwy $KE_2 = \frac{1}{2}mv_2^2$

Gssp 2 ,y nkhjj Mwwy

$$E_2 = U_2 + KE_2 = 2mgr + \frac{1}{2}mv_2^2$$

rkdghL cssthW Mwwy khwh tpjpggb

$$\frac{1}{2}mv_1^2 = 2mgr + \frac{1}{2}mv_2^2$$

khwwpaikff

$$\frac{1}{2}m(v_1^2 - v_2^2) = 2mgr$$

$$v_1^2 - v_2^2 = 4gr$$

rkdghL rkdghL gpujpal

$$T_1 - T_2 = \frac{m}{r}[4gr] + 2mg$$

vdNt ,Otpira\y khWghlhdJ

$$T_1 - T_2 = 6mg$$

Nkwgf;f Gs;spf (2) ,y; rpWk Ntfk;

nghUshdJ Gsspf 2 ,y xU rpWk Ntfjijf nfhzbUff Ntz Lk› ,yiynadpy Gsspf 2 l milAk Kdghf E}yhdj jshTwW mjdhy nghUs tllgghijia epiwT nraahJ. ,ej rpWk Ntfjijf fzffpl rkdghL ,y ,Otpir $T_2 = 0$ vdf nfhsNthk.

$$0 = \frac{mv_2^2}{r} - mg$$

$$\frac{mv_2^2}{r} = mg$$

$$v_2^2 = rg$$

$$v_2 = \sqrt{gr}$$

nghUshdJ tllgghijapy njhlhej ,aqf Gsspf 2 ,y $v_2 \geq \sqrt{gr}$ vdw Ntfjijf nfhzbUff Ntz Lk.

mbgGsspf (1) ,y rpWk Ntfk:

Gsspf 2 ,y ,ej rpWk Ntfjijg $\left(v_2 = \sqrt{gr}\right)$ngw nghUshdJ Gsspf 1 Yk xU rpWk Ntfjijf nfhzbUff Ntz Lk.

rkdghL lg gadgLjjp Gsspf 1 ,y rpWk Ntfjij ehk fhzyhk.

$$v_1^2 - v_2^2 = 4gr$$

rkdghL gpujpal

$$v_1^2 - gr = 4gr$$

$$v_1^2 = 5gr$$

$$v_1 = \sqrt{5gr}$$

nghUshdJ tllgghijapy njhlheJ ,aqf Gsspf 1 ,y $(v_1 \geq \sqrt{5gr})$vdw Ntfjijf nfhzbUff Ntz Lk.

rkdghLfs ,UeJ mwptJ vddntdpy nghUs tllgghijia tplL tpyfhky epiwT nraa mbgGsspf 1 ,y rpWk NtfkhdJ Nkwgff Gsspf 2 ,y csspf rpWk Ntfjij tpl $\sqrt{5}$ klqF ,Uff Ntz Lk.

vLj;Jf;fhl;L:

fa;wWld fllggll xU ths;a;y c s s eh 0.5 m MuKss nrqFjJ tlljij Rww; RowwggLf;wJ. ,affjj;d NghJ euhdJ ths;a;y ,UeJ r;ejhky ,Uff mbgGss;a;y ,Uff Ntzba r;Wk j;irNtfjijf fzff;Lf. ($g = 10\ ms^{-2}$)

jhT

tlljj;d Muk r = 0.5 m

Nkwgff Gss;a;y Njitahd Ntfk $v_2 = \sqrt{gr} = \sqrt{10 \times 0.5} = \sqrt{5} ms^{-1}$

mbggff Gss;a;y Ntfk $v_1 = \sqrt{5gr} = \sqrt{5} \times \sqrt{gr} = \sqrt{5} \times \sqrt{5} = 5 ms^{-1}$

j;wd; (Power):

j;wd;d; tiuaiw:

j;wd vdgJ vttsT Ntfkhf myyJ nkJthf xU Ntiy nraaggLf;wJ vdgjd msthFk. Ntiy nraaggLk tjk myyJ Mwwy nts;ggLk tjk› j;wd vd tiuaWffggLf;wJ.

$$\text{j;wd (P)} = \frac{\text{nraaggll Ntiy}(W)}{\text{vLj Jfnfhzl Neuk}\ (t)}$$

$$P = \frac{W}{t}$$

ruhrh;j; j;wd;:

nraaggll nkhjj Ntiyffk vLjJf nfhzl nkhjj Neujj;wFk ,ilNa c s s t;fijk ruhrh;jj;wd ($P_{ruhrh;}$)vd tiuaWffggLf;wJ.

$$(P_{ruhrh;}) = \frac{\text{nraaggll nkhjj Ntiy}}{\text{vLj Jfnfhzl nkhjj Neuk}}$$

cld;bj; j;wd;:

xU fz Neujj;y (Neu ,ilnts; Ro;ia neUqFk NghJ) nts;ggLk j;wd cldbj j;wd (P_{cldb})vd tiuaWffggLf;wJ.

$$(P_{cldb}) = \frac{dw}{dt}$$

j;wd;d; myF:

j;wd xU]Nfyh msthFk. mjd gh;khzk (ML^2T^{-3}) j;wd;d SI myF thl (W) vdW euht; ,aej;ujijf fzLgbjj N[k] thl ngauhy mioffggLf;wJ.

xU t;dhba;y xU [y Ntiy nraaggllhy j;wd xU thl vd tiuaWffggLf;wJ. ($1W = 1Js^{-1}$) f;Nyhthl (KW), nkfhthl (MW) kwWk [;fhthl (GW) Mf;ait j;wd;d cah myFfs MFk.

1 KW = 1000 W = 10^3 thl

1 MW = 10^6 thl

1 GW = 10^9 thl

Nkhllhhfs› ,aej;uqfs kwWk r;y jhd;aqf; thfdqfSfF Fj;iujj;wd (horse – power) (hp) vdwioffggLk j;wd;d gioa myfhdJ tz;fhj;ahf ,dDk gadghlby c s s J. Fj;iujj;wid (hp) thl (W) vdw myf;y khww

1hp = 746 W

midjJ k;d rhjdqfs;d kJk xU Fw;ggll j;wd;d msT mrr;lgglL toqffggLf;dwd. xU 100 thl t;sfF (bulb) xU t;dhba;y 100 [y k;d Mwwiy Efhf;wJ. [{y vdw myfhy msffggLk Mwwy;d j;wid thl

vdw myfpYk Neujij tpdhb vdw myfpYk Fwpggpl tjhy 1 J = 1 Ws vd vOjyhk. kpd cgfuzqfs gy kzp Neujpwf gadghlby cssNghJ mit mjpf mstpyhd Mwwiy EfUfpdwd. kpd Mwwiy thl tpdhb (Ws) vdw rpwpa myfpy mstpLkNghJ nghpa vz kjpgGfisf ifahs Ntzlk. vdNt kpd MwwyhdJ fpNyhthl kzp (kilowatt hour – kwh) vdw myfhy mstplggLfpwJ.

1 kpd myF (1 Apdpl) = 1 KWh = 1 (10^3W) × 3600 s)

1 kpd myF = 3600 × 10^3 Ws

1 kpd myF = 3.6 × 10^6 J

1 KWh = 3.6 10^6 J

kpd Mwwy EfhTfF KWh vdw myfpy kpdfllz glbayfs jahhpffggLfpdwd. 1 myF kpd Mwwy vdgJ 1KWh MFk.

(FwpgG: KWh vdgJ Mwwypd myF; jpwdpd myF myy)

vLj¡Jf¡fhl¡L:

xU 75 W kpdtprpwp jpdKk 8 kzp Neuk xU khjjpwF (30 ehlfs) gadgLjjggllhy Efuggll Mwwiy kpd myfpy fzffpLf.

jhT:

jpwd P = 75 W

gadghlL Neuk t = 8 kzp ×30 ehlfs = 240 kzp. Efuggll kpd MwwyhdJ jpwd kwWk gadghlL Neuk Mfpatwwpd ngUffy gyd MFk.

kpd Mwwy = jpwd ×gadghlL Neuk = P × t

= 75 thl ×240 kzp

= 18000 thl kzp

= 18 fpNyh thl kzp = 18 KWh

1 kpd myF = 1 KWh

kpd Mwwy = 18 myF

kpddpio tpsfFfs 1000 kzp Neuk xsptRk. CFL tpsfFfs 6000 kzp Neuk xsptRk. Mdhy LED tpsfFfs 50000 kzpNeuk xsptRk (Vwjjho 25 MzLfs› ehnshdWfF 5.5 kzp Neuk)

jpwd; kwWk; jpirNtfk; Mfpatwpwf;F ,ilNa cs;s njhlhG:

$\vec{F}$ vdw tpiradhy $d\vec{r}$ vdw ,lngahrrpfF nraaggll Ntiy

$$W = \int \vec{F}.d\vec{r}$$

rkdghL ,lJ gffjjpy cssij ,tthW vOjyhk.

$$W = \int dW = \int \frac{dW}{dt}dt$$

(dt - ,y ngUffTk tFffTk nraa)

jpirNtfk $\vec{v} = \frac{d\vec{r}}{dt}$ vdgjhy $d\vec{r} = \vec{v}dt$

rkdghL tyJ gffjjpy cssij ,tthW vOjyhk

$$\int \vec{F}.d\vec{r} = \int \left(\vec{F}.\frac{d\vec{r}}{dt}\right)dt = \int \left(\vec{F}.\vec{v}\right)dt \quad \text{éQ} \; \vec{v} = \frac{d\vec{r}}{dt}$$

rkdghL rkdghL ,y gujal

$$\int \frac{dW}{dt} dt = \left(\overline{F}.v\right) dt$$

$$\int \left(\frac{dW}{dt} - \overline{F}.v\right) dt = 0$$

,ej njhlhghdJ dt ,d vej xU jddrirahd kjggwFk rhahf cssJ. milgGfFwfFs css kjgG Roahf ,Uff NtzLk vdgij ,J Fwffw J. mjhtJ

$$\frac{dW}{dt} = -\overline{F}.v = 0 \text{ myyJ } \frac{dW}{dt} = \overline{F}.v$$

vLjJf;fhl;L:

1250 kg eiwAss xU thfdk xU rkkhd Neh rhiyay 0.2 ms^{-2} KLffjJld 500 N vdw vjhfFk Gwtirfnfjuhf ,affggLfwJ. thfdjjd jirNtfk 30 ms^{-1}vdy thfdjjd ,aejuk ntsggLjJk jwidf fzffLf.

jhT:

thfdjjd ,aejuk› vjhfFk tirfnfjuhf Ntiy nraJ thfdjij xU KLffjJld ,aff NtzLk. vdNt thfdjjd ,aejuk ntsggLjJk jwd.

P = (vjhfFk tir + (eiw ×Kffk) (jirNtfk)

$$P = \vec{F}_{tot}.\vec{V} = (F_{resistive} + F)V$$

$$P = \vec{F}_{tot}.\vec{V} = (F_{resistive} + ma)V$$

= (500 + (1250 ×0.2)) (30) = 22.5 kW

Nkhjy;fs; (Collisions):

Nkhjy vdgJ ekikr Rwwd mttgNghJ eilngwf$ba xU nghJthd eifoT MFk. cjhuzkhf Nfuk› gyyahl]› Nfhyfz L Nghdw tisahlLfs ,U nghUlfSffilNa Nkhjyfshd J njhLjYld myyJ njhLjydw Vwglyhk.

midjJ Nkhjy nrayKiwfsYk NehfNfhlL cejk khwhJ. ,U nghUlfs NkhjYwwhy mtwwwfilNa nraygLk rkkhd fzjjhfF tirfs Dtvdw NkhjYWk Neujjy mtwwd cejqfsy khwwjij VwgLjJfwJ. mjhtJ Kjy nghUs $\vec{F}_{12}$vdw tiria ,uzlhtJ nghUsd kJ nrYjJfwJ. mNjNghy eAilldd %dwhk tjggb› ,uzlhtJ nghUshdj Kjy nghUsd kJ $\vec{F}_{21}$vdw tiria nrYjJfwJ. ,it Kjy kwWk ,uzlhtJ nghUlfsd cejjjy KiwNa D$\vec{P}_1$kwWk D$\vec{P}_2$vdw khwwjij VwgLjJfwJ. jwNghJ ,jd njhlhGfis foffzlthW vOjyhk.

$$D\vec{p}_1 = \vec{F}_{12} Dt$$

$$D\vec{p}_2 = \vec{F}_{21} Dt$$

rkdghL ,uzilAk $ll

$$D\vec{P}_1 + D\vec{P}_2 = \vec{F}_{12} Dt + \vec{F}_{21} Dt = \left(\vec{F}_{12} + \vec{F}_{21}\right) Dt$$

e)A+lld)d %dwhk t)j)ggb $\vec{F}_{12} = -\vec{F}_{21}$

$$D\vec{P}_1 + D\vec{P}_2 = 0$$

$$D(\vec{P}_1 + \vec{P}_2) = 0$$

,UGwKk Δt - My tFff› kwWk vy)iy $\Delta t \to 0$ vdf nfhss ehk ngWtJ

$$\lim Dt \to 0 \frac{D(\vec{p}_1 + \vec{p}_2)}{Dt} = \frac{d(\vec{p}_1 + \vec{p}_2)}{dt} = 0$$

Nkwfzl rkdghL nkhjj NehfNfhlL cejk xU khwh msT vdgijf Fw)ff)wJ.

Fw)gG: cejk xU ntflh msthFk. vdNt Nkhjy)d NghJ jd)jjd) nghUlfs)d cejjijf fhz ntflh $Ljy g)dgwwggl Ntz Lk.

Nkhjy)fs)d; tiffs;
vej xU Nkhjy nrayKiwa)Yk nkhjj NehfNfhlL cejKk› nkhjj MwwYk vgNghJk khwhJ. mNjrkak nkhjj ,aff MwwyhdJ vgNghJk khwhky ,Uffj Njita)yiy. njhlff ,aff Mwwy)d xU gFj) NtW tifahd Mwwyhf khwwkilf)wJ. Vnddwhy Nkhjyfs kwWk Nkhjyfshy VwgLk cUfFiyT Mfatww)d jhffk nghJthf ntggk› xy) xs) Nghdwtwiw cUthfFf)wJ. ,ej t)isTfis fzff)y nfhzL Nkhjyfis ehk foffzlthW tifggLjjyhkl.

a. klr) Nkhjy
b. klr)aww Nkhjy

klr) Nkhjy; (Elastic Collision):
xU Nkhjy)y nghUlfs)d njhlff nkhjj ,aff MwwyhdJ (NkhjYfF Kd) nghUlfs)d ,Wj) nkhjj ,aff MwwYfF (NkhjYfFg g)d) rkkhf ,Uejhy mJ klr)Nkhjy vdggLk. mjhtJ
NkhjYfF Kd nkhjj ,aff Mwwy = NkhjYfFg g)d nkhjj ,aff Mwwy

klr)aww Nkhjy; (Inelastic collision):
xU Nkhjy)y nghUlfs)d njhlff nkhjj ,aff MwwyhdJ (NkhjYfF Kd) nghUlfs)d ,Wj) nkhjj ,aff MwwYfF (NkhjYfFg g)d) rkkhf ,yiynad)y mJ klr)aww Nkhjy vdggLk. mjhtJ
NkhjYfF Kd nkhjj ,aff Mwwy ¹ NkhjYfFg g)d nkhjj ,aff Mwwy

NkhjYfF Kd — NkhjYfFg g)d
nkhjj ,aff Mwwy - nkhjj ,aff Mwwy
= (Nkhjy)d NghJ Mwwy ,ogG) = ΔQ

,aff Mwwy khWk vd)Dk nkhjj Mwwy khwhJ. vndwhy nkhjj MwwyhdJ ,lff Mwwy)d rkdghL kwWk Nkhjy)d NghJ Vwgll midjJ ,ogGfisAk csslff)a rkdghL (ΔQ) Mfatwiwf nfhzLssJ. Nkhjy)d NghJ ,aff Mwwy)y VwgLk ,ogG xy) ntggk Nghdw NtW tifahd Mwwyhf khwwkilf)wJ vdgij mw)aTk. NkYk NkhjYWk ,U nghUsfSk NkhjYfFg g)d xdWld xdW xlbfnfhzlhy mttif Nkhjyfs KO klr)awwNkhjy myyJ klr)aww Nkhjy vdggLk. mttifahd Nkhjiy mbffb fhzyhk. cjhuzkhf›ukhd› xU fs)kz cUzil (myyJ gg)sfk) xU ,aqFk thfdjj)d kJ vw)aggllhy› mJ ,aqFk thfdjJld xlbf nfhsf)wJ kwWk mit rk j)irNtfjJld ,aqFf)dwd.

xU ghpkhz klq;rp Nkhjy;fs;

m_1 kwWk m_2 epiwAss ,U klrpg nghUsfs fhlbAsthW xU cuhatww fpiljjsg guggpy NehfNfhlby (Neh x - mrrpd jpirapy) ,aqFtjhff fUJf.

klq;rp kwWk; klq;rpaww Nkhjy;fis xggpLjy;:

t.vz	klq;rp Nkhjy;	klq;rpaww cejk; khwhJ
1.	nkhjj cejk khwhJ	nkhjj cejk khwhJ
2.	nkhjj ,aff Mwwy khwhJ	nkhjj ,aff Mwwy khWk
3.	njhlhGila tpirfs Mwwy khwwh tpirfs	njhlhGila tpirfs Mwwy khwWk tpirfs
4.	,aejpu Mwwy rpijtilahJ	,aejpu MwwyhdJ ntggk> xsp> xypNghdwitahf ntspggLfpwJ.

epiw	njhlf;f jpirNtfk;	,Wjp jpirNtfk;
epiw m_1	u_1	v_1
epiw m_2	u_2	v_2

Nkhjy epfo epiw m_1 epiw m_2 l tpl Ntfkhf ,aqFtjhff fUJf. mjhtJ u_1> $u_2$klrp NkhjYfF ,U nghUsfspd nkhjj NehfNfhlL cejk kwWk ,aff Mwwyfs NkhjYfF KdGk NkhjYfFg gpdGk khwhky xNu msthf ,Uff Ntz Lk.

	epiw m_1,d; cejk;	epiw m_2,d; cejk;	nkhjj NehfNfhlL cejk;
NkhjYfF Kd	$P_{i1} = m_1u_1$	$P_{i2} = m_2u_2$	$P_i = P_{il} + P_{i2}$ $P_i = m_1u_1 + m_2u_2$
NkhjYfF gpd	$P_{f1} = m_1v_1$	$P_{f2} = m_2v_2$	$P_f = P_{f1} + P_{f2}$ $P_f = m_1v_1 + m_2v_2$

NehfNfhlL cej khwh tpjpay ,UeJ NkhjYfF Kd nkhjj cejk (P_i) = NkhjYfFg gpd nkhjj cejk (P_f)

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

myyJ

$m1(u_1 - v_1) = m_2 (v_2 - u_2)$

NkYk

	epiw m_1,d; ,aff Mwwy;	epiw m_2,d; ,aff Mwwy;	nkhjj ,aff Mwwy;
NkhjYfF Kd	$KE_{i1} = \frac{1}{2}m_1u_1^2$	$KE_{i2} = \frac{1}{2}m_2u_2^2$	$KE_i = KE_{i1} + KE_{i2}$ $KE_i = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$
NkhjYfFg gpd	$KE_{f1} = \frac{1}{2}m_1v_1^2$	$KE_{f2} = \frac{1}{2}m_2v_2^2$	$KE_f = KE_{f1} + KE_{f2}$ $KE_f = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

klrp NkhjYfF

NkhjYfF Kd nkhjj ,aff Mwwy KE_i = NkhjYfFg gpd nkhjj ,aff Mwwy Ke_f

RUff;a gwF khwwpaikff $m_1(u_1^2 - v_1^2) = m_2(v_2^2 - u_2^2)$

Nkwfzl rkdghlil $a^2 - b^2 = (a + b)(a - b)$

vdw thagghlilg gadgLjjp kzLk vOj

$$m_1(u_1+v_1)(u_1-v_1) = m_2(v_2+u_2)(v_2-u_2)$$

rkdghL tFff fpilggJ

$$\frac{m_1(u_1+v_1)(u_1-v_1)}{m_1(u_1-v_1)} = \frac{m_2(v_2+u_2)(v_2-u_2)}{m_2(v_2-u_2)}$$

$u_1 + v_1 = v_2 + u_2$

khwwpaikff

$u_1 - u_2 = v_2 - v_1$

rkdghL ,tthW vOjyhk.

$u_1 - u_2 = -(v_1 - v_2)$

,jd nghUshdJ vejxU Neub klrp Nkhjypyk> NkhjYffFggpd ,U klrpg nghUsfspd xgGikNtfk NkhjYfF Kd ,Uej mNj vz kjpgigf nfhzLk Mdhy vjphjjpirapYk ,UfFk vdgjhFk. NkYk ,ej KbT epiyiar rhhejjyy vdgij mwpaTk.

Nkwfzl rkdghlbypUeJ $v_1$kwWk $v_2$kjpgGfisf fhz

$$v_1 = v_2 + u_2 - u_1$$

myyJ

$$v_2 = u_1 + v_1 - u_2$$

,Wjp jpirNtfqfs $v_1$kwWk $v_2$fzlwpjy:

rkdghL gupjpaplLtjd %yk m_1 ,d jpirNtfkhdJ

$m_1(u_1 - v_1) = m_2(u_1 + v_1 - u_2 - u_2)$

$m_1(u_1 - v_1) = m_2(u_1 + v_1 - 2u_2)$

$m_1u_1 - m_1v_1 = m_2u_1 + m_2v_1 - 2m_2u_2$

$m_1u_1 - m_2u_1 + 2m_2u_2 = m_1v_1 + m_2v_1$

$(m_1 - m_2)u_1 + 2m_2u_2 = (m_1 + m_2)v_1$

myyJ $v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$

,J NghdNw rkdghL gupjpapl myyJ rkdghL gupjpapl m_2 ,d ,Wjp jpirNtfkhdJ

$$v2 = \left(\frac{2m_1}{m_1 + m_2}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 - m_2}\right)u_2$$

nghUsfs xNu epiwiaf nfhzbUejhy mjhtJ $m_1 = m_2$

rkdghL $v_1 = (0)u_1 + \left(\frac{2m_2}{2m_2}\right)u_2$

$v_1 = u_2$

rkdghL Þ $v_2 = \left(\frac{2m_1}{2m_1}\right)u_1 + (0)u_2$

$v_2 = u_1$

rkdghLfs kwWk njhptpggJ vddntdpy xU ghpkhz klrp Nkhjypy rk epiwAss ,U nghUsfs Nkhjpfnfhzlhy NkhjYfFg gpd mtwwpd jpirNtfqfs ghpkhwpf nfhssggLfpdwd.

nghUsfs xNu epiwiaf nfhzbUejhy› mjhtJ $m_1 = m_2$ kwWk ,uzlhtJ nghUs (toffkhf ,yfF vd mioffggLtJ) xaT epiyapy css NghJ ($u^2 = 0$)

$m_1 = m_2$kwWk ($u_2 = 0$) vdw kjpgGfis rkdghLfs ,y gpujpapl

rkdghL Þ $v_1 = 0$

rkdghL Þ $v_2 = u_1$

rkdghL kwWk njhptpggJ vddntdpy Kjy nghUs NkhjYfFg gpd xaT epiyfF tUkNghJ ,uzlhtJ nghUs Kjy nghUspd njhlff jpirNtfjjpy ,aqFfpwJ.

Kjy nghUshdJ ,uzlhtJ nghUspd epiwia tpl Fiwthf ,Uejhy› $m_1 << m_2, \frac{m_1}{m_2} << 1$ gpwF tpfpjk $\frac{m_1}{m_2} \approx 0$ kwWk ,yfF xaT epiyapy cssNghJ ($u_2 = 0$) rkdghL ,d njhFjp kwWk gFjpia m_2My tFfff

$$v_1 = \left(\frac{\frac{m_1}{m_2} - 1}{\frac{m_1}{m_2} + 1}\right) u_1 + \left(\frac{2}{\frac{m_1}{m_2} + 1}\right) (o)$$

$$v_1 = \left(\frac{0 - 1}{0 + 1}\right) u_1$$

$$v_1 = u_1$$

,J NghdNw›

rkdghL njhFjp kwWk gFjpia m_2 – MytFfff

$$v_2 = \left(\frac{2\frac{m_1}{m_2}}{\frac{m_1}{m_2} + 1}\right) u_1 + \left(\frac{1 - \frac{m_1}{m_2}}{\frac{m_1}{m_2} + 1}\right)$$

$$v_2 = (O) u_1 + \left(\frac{1 - \frac{m_1}{m_2}}{\frac{m_1}{m_2} + 1}\right)$$

epiw Fiwthf css Kjy nghUshdJ mNj njhlff jpirNtfjJld vjphjjpirapy jpUkGfpwJ (kznlOfpwJ) vdgijr rkdghL css vjphfFwp FwpffpwJ. mjpf epiwAss ,uzlhtJ nghUshdJ NkhjYfFg gpwFk xaT epiyapNyNa njhlheJ ,UffpwJ vdgijr rkdghL FwpffpwJ. vLjJffhllhf› geJ xdW epiyahd Rthpd kJ vwpaggllhy gejhdJ vwpaggll mNj jpirNTfjjpNyNa vjphjjpirapy Rthpy ,UeJ jpUkgp tUk.

NehT 4: ,uzlhtJ nghUshdJ Kjy nghUistpl epiw Fiwthf cssNghJ›

$$\left(m_2 << m_1, \frac{m_2}{m_1} << 1\right) \text{ gwF } t\text{pfpjk } \frac{m_2}{m_1} \approx 0$$

kwWk ,yfF xaT epiyapy cssNghJ ($u_2 = 0$) rkdghL ,d njhFjp kwWk gFjpia m_1-My tFfff

$$v_1 = \frac{\left(1 - \frac{m_2}{m_1}\right)}{\left(1 + \frac{m_2}{m_1}\right)} u_1 + \frac{\left(2\frac{m_2}{m_1}\right)}{\left(1 + \frac{m_2}{m_1}\right)} (O)$$

$$v_1 = \frac{(1 - 0)}{(1 + 0)} u_1 + \frac{0}{(1 + 0)} (0)$$

$$v_1 = u_1$$

,J Nghdnw›
njhFjp kwWk gFjpia m_1-My tFfff

$$v_2 = \frac{2}{\left(1 + \frac{m_2}{m_1}\right)} u_1 + \frac{\left(\frac{m_2}{m_1} - 1\right)}{\frac{m_2}{m_1}} (O)$$

$$v_2 = \frac{2}{(1 + 0)} u_1$$

$$v_2 = 2u_1$$

fdkhf css Kjy nghUshdJ NkhjYfFg gwF mNj jpirNtfjJld njhlheJ ,aqFfpwJ vdgijr rkdghL Fwpffpwj. epiw Fiwthf css ,uzlhtJ nghUs Kjy nghUspd njhlff jpirNtfjijg Nghy ,U klqF jpirNtfjJld ,aqFfpwJ vdgijr rkdghL Fwpffpwj. epiw Fiwthf css nghUs NkhjYWk Gsspaypueh Ntfkhfr nryfpwJ.

vLj¡Jf¡fhl¡L:
10 m s^{-1}Ntfjjpy ,aqFk xU epiw Fiwthd nghUs mjd epiwiag NghdW ,U klqF kwWk mjd Ntfjjpy ghjpasT nfhzl mNj jpiraypy ,aqFk kwnwhU nghUspd kJ NkhJfpwJ. Nkhjyhdj xU ghpkhz klrp Nkhjy vdf fUJf. NkhjYfFg gwF ,U nghUsfspd Ntfk vdd?

jhT:

Kjy nghUspd epiw m vdf› kwWk mjd njhlff jpirNtfk $u_1 = 10\ ms^{-1}$, vdNt ,uzlhtJ nghUspd epiw 2m kwWk mjd njhlff jpirNtfk

$$u_2 = \frac{1}{2} u_1 = \frac{1}{2} (10 ms^{-1})$$

rkdghLfs kwWk ,U nghUsfspd ,Wjp jpirNtfqfisf fzffplyhk.

$$v_1 = \frac{(m_1 - m_2)}{(m_1 + m_2)} u_1 + \frac{2m_2}{(m_1 + m_2)} u_2$$

$$v_1 = \left(\frac{m - 2m}{m + 2m}\right)10 + \left(\frac{2 \times 2m}{m + 2m}\right)5$$

$$v_1 = \left(\frac{-1}{3}\right)10 + \left(\frac{4}{3}\right)5 = \frac{-10 + 20}{3} = \frac{10}{3}$$

$v_1 = 3.33\ ms^{-1}$

$$v_2 = \left(\frac{2m_1}{m_1 + m_2}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2$$

$$v_2 = \left(\frac{2m}{m + 2m}\right)10 + \left(\frac{2m - m}{m + 2m}\right)5$$

$$v_2 = \left(\frac{2}{3}\right)10 + \left(\frac{1}{3}\right)5 = \frac{20 + 5}{3} = \frac{25}{3}$$

$v^2 = 8.33\ ms^{-1}$

v_1 kwWk v_2 Mfpa ,U Ntfqfspk NehfFwpahf cssjhy mit ,uzLk KiwNa 3.33 m s^{-1} kwWk 8.33 ms^{-1} vdw jpirNtfqfSld NkhjYfF Kd ,aqfpa jpiranyNa ,aqFfpdwd.

KO klr;rpaww Nkhjy; (Perfect Inelastic Collision):

KO klrpaww Nkhjypy nghUsfs NkhjYfFggpwF xU nghJthd jpirNtfjjpy ,aqFk tifapy xdWld xdW epuejukhf xlbfnfhsfpdwd. $m_1$kwWk $m_2$epiw nfhzl xU nghUsfs NkhjYfF Kd KiwNa $u_1$kwWk $u_2$vdw njhlff jpirNtfqfSld ,aqFtjhff nfhsf. KO klrpaww NkhjYfFg gpwF nghUlfs v vdw nghJthd jpirNtfjJld xdwhf ,aqFfpdwd.
Nkhjypd NghJ NehfNfhlL cejk khwwgglhky cssjhy

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2)\, v$$

NkhjYfF Kd NkhjYfFg gpd

nghUs;	jpirNtfk;		NehfNfhlL cejk;	
	njhlf;fk;	,Wjp	njhlf;fk;	,Wjp
epiw m_1	u_1	v	m_1u_1	m_1v
epiw m_2	u_2	v	m_2u_2	m_2v
	nkhjjk		$m_1u_1 + m_2u_2$	$(m_1+m_2)\, v$

nghJthf jpirNtfjij foffzlthW fzffplyhk.

$$v = \frac{m_1u_1 + m_2u_2}{(m_1 + m_2)}$$

vLj;Jf;fhl;L:
50 g epiwAss xU Jgghffp FzL 450 g epiwAss xU njhqftplggll nghUspd mbggFjpapypUeJ RlggLfpwJ. Jgghffp FzL nghUspDs nghjpeJ nghUshdJ 1.8 m caujpwF NkyNehffpr nryfpwJ. Jgghffp Fzbd Ntfjijf fzffpLf.

g = 10 ms^{-2}vdf nfhsf.

jhT:

$m_1 = 50\ g = 0.05\ kg;\ m_2 = 450\ g = 0.45\ kg$

Jgghff; Fzbd Ntfk u_1MFk. ,uzlhtJ nghUs XaT e;iya;y cssJ (u_2 = 0) Jgghff; FzL nghUs;Ds nghj;ej g;wF Jgghff; FzL kwWk nghUs Mf;atww;d nghJthd j;irNtfk v vdf.

$$v = \frac{m_1u_1 + m_2u_2}{(m_1 + m_2)}$$

$$v = \frac{0.05u_1 + (0.45 \times 0)}{(0.05 + 0.45)} = \frac{0.05}{0.50}u_1$$

nghJthd j;irNtfkhdJ Jgghff; FzL kwWk nghUs Mf;a xUqf;izej mikgg;d NkyNehff;a nrqFjJ ,affjj;wfhd njhlff j;irNtfk MFk. ,uzlhtJ ,affr rkdghlby;UeJ

$$v = \sqrt{2gh}$$

$$v = \sqrt{2 \times 10 \times 1.8} = \sqrt{36}$$

$$v = 6\ ms^{-1}$$

,jid Nkwfzl rkdghlby g;uj;a;lL U_1 kj;giggngw

$$6 = \frac{0.05}{0.50}u_1 \quad \text{myyJ} \quad u_1 = \frac{0.50}{0.05} \times 6 = 10 \times 6$$

$$u_1 = 60 ms^{-1}$$

KO kl;rpawW Nkhjy;y; VwgLk; ,af;f Mwwy; ,ogG:

KO klrpaww Nkhjy;d NghJ ,aff Mwwy;d ,ogghdJ xy> ntggk> xs; Nghdw NtW tifahd Mwwyhf khwwggLf;wJ. NkhjYfF Kd nkhjj ,aff Mwwy KE;ikwWk NkhjYfFgg;d nkhjj ,aff Mwwy EK;fvdf nfhsf.

$$KE_i = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$$

NkhjYfFg g;d nkhjj ,aff Mwwy

$$KE_f = \frac{1}{2}(m_1 + m_2)v^2$$

vdNt ,aff Mwwy;y VwgLk ,ogG

$\Delta Q = KE_i - KE_f$

$$= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1 + m_2)v^2$$

rkdghL rkdghL ,y g;uj;a;lL $(a + b)^2 = a^2 + b^2 + 2ab$ vdw ,awfzj rkdghlilg gadgLjj> RUff ehk ngWtJ.

kl;rpasp;gG Fzfk; (e)(Coefficient of restitution):

,U ,uggh geJ kwWk xU g;sh]bf geJ ,uzilAk xNu jsjj;y tpornratjhff nfhsNthk. ,uggh gejhdJ g;sh]bf geijtpl mj;f caujj;wF NknyOkGk. Vnddwhy xU klrpg gzGss ,uggh gej;wF ,aff Mwwy;d ,ogG g;sh]bf gej;wF ,aff Mwwy;d ,ogG g;sh]bf gej;wfhd ,ogigtpl k;f FiwthFk. nghJthf NkhjYfFg g;wF ,U nghUsfs;d ,aff Mwwy kj;gg;id

klrasgG Fzfk (Coefficient of Restitution – COR) vdggLk xU ghkhzkww vz %ykhf msejwayhk.

NkhjYfFg gd css tyFk jirNtfjjwFk (rhhGj jirNtfk) NkhjYfF Kd css neUqFk jirNtfjjwFk (rhhGj jirNtfk) ,ilNa css tfjk klrasgG Fzfk vd tiuaWffggLfwJ.

mjhtJ

$$e = \frac{\text{tyFk jirNtfk (NkhjYfFg gd)}}{\text{neUqFk jirNtfk (NkhjYfF gd)}}$$

$$= = \frac{(v_2 - v_1)}{(u_1 - u_2)}$$

klr Nkhjyy tyFk jirNtfkhdJ neUqFk jirNtfjjwF rkk vd filffg ngwNwhk.

mjhtJ

$$(u_1 - u_2) = (v_2 - v_1) \Rightarrow \frac{(v_2 - v_1)}{(u_1 - u_2)} = 1 = e$$

klr NkhjYfF klrasgG Fzfk e = 1 vdgij ,J Fwffwj. ,aygh› NkhjYfFg gwF ,aff Mwwyy ,ogG VJkyiy vdgNj ,jd nghUshFk. vdNt nghUshdJ mNj ,aff MwwYld NknyOkGfwJ. ,J toffkhf KO klr vd mioffggLfwJ. vttj czikahd Nkhjy efoTfsYk Nkhjydhy ,aff Mwwyy VjhtJ ,ogG VwgLk. ,jd nghUs e ,d kjgG vgnghOJk 1 – l tlf Fiwthf ,UfFk. KOikahd gsh]bf gejhf ,Uejhy mJ kzLk NknyOkghJ. Mifahy NkhjYfFg gwF mtwwd tyFk jirNtfk Roahfk. vdNt klrasgG Fzfjjd kjgG e = 0.

nghJthf› xU nghUsd klrasgG Fzfk 0 < e < 1 vd ,UfFk.

vLj;Jf;fhl;L:

xU klraww Nkhjyy xU nghUs eiyahf cssNghJ rkeiwfs nfhzl nghUsfsd jirNtfqfsd tfjk $\frac{v_1}{v_2} = \frac{1-e}{1+e}$ vdf fhlLf.

jhT:

$$e = \frac{\text{tyFk jirNtfk (NkhjYfFg gd)}}{\text{neUqFk jirNtfk (NkhjYfF gd)}}$$

$$= = \frac{(v_2 - v_1)}{(u_1 - u_2)} = \frac{(v_2 - v_1)}{(u_1 - 0)} = \frac{(v_2 - v_1)}{u_1}$$

$$\therefore v_2 - v_1 = eu_1$$

NehfNfhlL cejk khwh tjjaylUeJ

$$mu_1 = mv_1 + mv_2 \therefore u_1 = v_1 + v_2$$

rkdghL (2) ,y css u_1,d kjgig rkdghL (1) ,y gujal

$$v_2 - v_1 = e(v_1 + v_2)$$

,jidr RUff

$$\frac{v_1}{v_2} = \frac{1-e}{1+e}$$

12th ,awgpay;
myF – 1
epiykpd;dpay;

mwpKfk;:

kpdfhejtpaply vdgJ ,awgpaypd kpf Kffpakhd gphTfspy xdwhFk. 21 Mk E}wwhzbd njhopyElg tshrrpfs gyTk kpdfhejtpaiyg gwwpa ekJ Ghpjypdhy VwglLitNa.

mdwhl thotpy ehk fhZk tpirfSs><hgg tpiriaj jtpu gpw midjJ tpirfSk kpdfhej ,ayG nfhzlitNa.

<hgG tpir> ,Otpir> cuhaT tpir> nrqFjJ tpir csspll tpirfisg gwwp mit xtnthdiwAk jdpjj ,ayGila tpirahfTk xdiwnahdW rhhejit myy vdWk epA+lld fUjpdhh. mggbnadpy ,ttpirfspd Njhww %yk jhd vdd? jwNghija Ghpjygb> ek mdwhl thotpy ehk vjphnfhsSk tpirfSs <hgG tpiriaj jtpu gpw tpirfs midjJk (fkgpapd ,Otpir> guggpd nrqFjJ tpir> cuhaT tpir csspllit) mZffSfF ,ilNa NjhdWk kpdfhej tpirfNs. rpy vLjJffhlLfs fNo jugglLssJ.

1. nghUnshdW jssggLk NghJ> ek iffspy csspd mZffSld mgnghUspYss mZffs ,iltpid (interact) Ghpfpdwd. ,ej ,iltpid tpirahdJ kpdfhej ,aygNa ngwWssJ.

2. Gtpgguggpd kJ ehkl epwFkNghJ> ek kJ GtpahgG tpir foNehffpa jpirapy nraygLfpwJ. jiuapd nrqFjJ tpir NkyNehffpa jpirapy nrayglL mij rkd nrafpwJ ,ej nrqFjJ tpirapd Njhww %yk vdd?
Gtpgguggpd NkYss mZffSfFk ek ghjqfspYss mZffSf:Fk ,ilNa epfOk ,iltpidapd fhuzkhfNt ,ttpir cUthfpwJ. czikapy><hgG tpirapdhy ehk <uffggLk epiyapy mZffSfF ,ilNa cUthFk kpdfhej tpirapdhy jhd Gtpapd Nky ekkhy epwf Kbfpwj.

3. gugG xdwpd kJ xU nghUisj jsSkNghJ> mJ efu KwgLtij xaTepiy cuhaT jLfFk. ,ej xaT epiy cuhathdJ guggpYss mZffSfFk nghUspYss mZffSfFk ,ilNa VwgLk kpdfhej ,iltpidahy cUthfpdwJ. ,affepiy cuhaTk ,jjifa Njhww%yk nfhzlNj.

vdNt gpugQrjijg gwwpa KOikahd GhpjYfF kpdfhejtpaiyg gwwpa Ghpjy ,dwpaikahjJ vdW ,ej vLjJffhlLfs %yk njspthfpdwJ. kpdfhejtpaypd mbggilj jjJtqfis ,awgpaypd Kjy njhFjpapy mwpeJ nfhssyhk. epiyahf csspd kpdJfsfspd jdik gwwpAk mJ njhlhghd epfoTfs gwwpAk ,ej myfpy $wgglLssJ. epiyahf csspd kpdJfsfisg gwwp mwpa cjTk kpddpaypd ,ejg gphT epiy kpddpay vdggLk.

tuyhwpW gpdGyk; - kpd;D}l;lq;fs;:

mufF (amber) vdggLk xU tifg nghUis (,J xspfrpAk jdikAila> Gijggbkkhf khwpa xU tif kuggprNd) tpyqF cNuhkk myyJ fkgspnfhzL Njaejhy mJ rpW ,iyfisAk J}rpidAk fthtij Rkhh ,uzlhapuk MzLfSfF KddNu gzila fpNuffhfs fzLssdh. ,jjifa gzigg ngwWss mufF 'kpdD}llk ngwWssJ' vdyhk. njhlffjjpy mufF klLNk ,ej rpwggpayG csspjhf fUjggllJ. Mdhy> gpddhspy glLjJzpahy Njaffggll fzzhbj jzLk fhfpjj JzLfisf fthtJ fzlwpagglIJ. vdNt> jFej

nghUisf nfhzL NjaffggLk fz zhbj jzLk $l 'kdD}llk ngWk' jdik nfhzLssJ.

,gNghJ kdD}llk ngww fz zhbj jzL xdiw ,uggh jzbd mUfy nfhzL nryYk NghJ› mit xdiwnahdW ftUfdwd. mNj rkak› kdD}llk ngww fz zhbj jzbid kdD}llk ngww ,dndhU fz zhbj jzbd mUfy nfhzL nrdwhy mit xdiwnahdW tyfFtijf fhzyhk.

,ejfhl;rfawTfsd; (Observations) %yk; gd;tUk; KbTfisf; $wyhk;

1. ,uggh jzL ngww kdD}llk fz zhbj jzL ngww kdD}lljjyUeJ NtWgllJ.

2. kdD}llk ngww ,uggh jzL kdD}llk ngww ,dndhU ,uggh jzbid tyfFfwJ. ,jyUeJ› Xhd kdD}llqfs xdiwnahdW tyfFfdwd vdyhk. kdD}llk ngww fz zhbj jzil kdD}llk ngww ,dndhU fz zhbj jzL tyfFk nrayghlbyUeJk ,Nj Kbit vllyhk.

3. kdD}llk ngww ,uggh jzil kdD}llk ngww fz zhbj jzL ftUfdwJ. ,jyUeJ fz zhbj jzbYss kdD}llKk ,ugghYss kdD}llKk xNu tifayy vdgJ Ntwd kdD}llqfs xdiwnahdW ftUfdwd vdgJ njha tUfdwJ.

gugQrjjy ,U tif kdD}llqfNs cssd. xU tifia Neh kdD}llk (+) vdTk ,dndhU tifia vjh kdD}llk (-) vdTk ngQrkd guhqfsd vdgth 18-k E}wwhzby tifggLjjdhh. ,kkugggb› kdD}llk ngww ,uggh kwWk mufFj jzLfs vjh kdD}llk ngwwit vdWk› kdD}llk ngww fz zhbj jzL Neh kdD}llk ngwwJ vdWk vLjJfnfhssggLfdwd. xU nghUsYss efu (net) kdD}llk Rohad› mgnghUs kd eLeiyay cssJ vdyhk.

19k E}wwhzbd ,WjaYk 20 k E}wwhzbd njhlffjjYk jk Muharrfis Nkwnfhzl N[.N[. jhkrd› V.&jhNghhL Nghdw mwtay mwQhfsd KdNdhb MaTfsd %yk mZthdJ kd eLeiy nfhzlJ vdW mwaggllJ. NkYk› mZthdJ vjh kdD}llk nfhzl vyfluhdfs› Neh kdD}llk nfhzl GNuhllhdfs kwWk kd eLeiyik nfhzl eAluhdfs Mfatwwhy MdJ vdWk ehk mwfNwhk. nghJthf› midjJg nghUsfSk mZffshy Mdit vdgjhy mitAk kd eLeiyik nfhzlitNa. xU nghUis kwnwhU nghUSld NjafFkNghJ (vLjJffhllhf› ,uggiu glLjJzahy NjafFkNghJ) vjh kdJfsfs ryytwiw mgnghUs ,offdwJ myyJ ngWfdwJ. ,jdhy jhd mgnghUs kdD}llk ngwwjhfdwJ. ,kKiwa› mjhtJ› cuhatd %yk nghUsfis kdNdwwk (Charging) nraAk Kiw 'cuhaT kdNdwwk' vdggLk.

kd;D}l;lj;jd; mbggilg; gzGfs;
kd;D}l;lk;

gugQrjjYss nghUsfs midjJk mZffshy Mdit› mZffs GNuhllhdfs› eAluhdfs kwWk vyfluhdfshy Mdit. ,it midjJNk eiw vDk csshhej (inherent) gzig cilait. ,NjNghy› kdD}llk vdgJk kwnwhU csshhej mbggilg gzghFk. 19Mk kwWk 20 Mk E}wwhzLfsy Nkwnfhssggll gyNtW MaTfsd %yk kdJfsd ,ayigg gwwa Ghjy VwgllJ. kdD}lljjd SI myF $Y}k (C) MFk.

xU nghUs ,dndhdwhy NjaffggLkNghJ xdwyUeJ kwnwhdwwF kdJfsfs ,lk ngahfdwd vd ngQrkd guhqfsd thjllhh. NjaffggLk Kd nghUsfs kd eLeiyay cssd. NjaffggLk NghJ xdwyUeJ kwnwhU xU nghUs ,dndhdwhy NjaffggLkNghJ xdwyUeJ kwnwhdwwF kdJfsfs ,lk

ngahf‌dwd vd ngQrk‌d g‌uhqfs‌d thj‌llhh. NjaffggLk Kd nghUsfs k‌d eLe‌iya‌y cssd. NjaffggLk NghJ xdw‌y‌UeJ kwnwhU nghUSfF k‌dJfsfs ,lkl ngahf‌dwd. (vLjJffhllhf› fzzhb jzbid glLj Jz‌ahy NjafFkNghJ› vj‌hk‌dD}llk ngww k‌dJfsfs fzzhbj jzby‌UeJ glLjJz‌fF ,lk ngahf‌dwd. ,jdhy fzzhbj jzL e‌fu Neh k‌dD}lljijAk ngWf‌dwd). ,jjifa fhlr‌aw‌Tfs‌y‌UeJ 'k‌dD}llqfis MffNth mo‌ffNth ,ayhJ' vdWk mtwiw xU nghUs‌y‌UeJ kwnwhU nghUSfF ,lkhwwk nraa klLNk ,aYk' vdWk mth $w‌dhh. ,ijNa nkhjj k‌dD}ll khwhj jdik vdgh. glLjJz‌fF ,lk ngahf‌dwd. ,jdhy fzzhbj jzL e‌fu Neh k‌dD}lljijAk glLjJz‌ e‌fu vj‌h k‌dD}lljijAk ngWf‌dwd). ,jjifa fhlr‌aw‌Tfs‌y‌UeJ 'k‌dD}llqfis MffNth mo‌ffNth ,ayhJ' vdWk 'mtwiw xU nghUs‌y‌UeJ kwnwhU nghUSfF ,lkhwwk nraa klLNk ,aYk' vdWk mth $w‌dhh. ,ijNa nkhjj k‌dD}ll khwhj jdik vdgh.

,J ,awg‌ay‌y mw‌aggLk khwhj jdik t‌j‌fSs (Conservation laws) mbggilahd xdwhFk. ,tt‌j‌ia nghJggilahfg g‌dtUkhW $wyhk. g‌ugQrjj‌Yss nkhjj k‌dD}llk khwhky ,UfFk. k‌dD}lljij MffNth mo‌ffNth ,ayhJ. vejnthU ,awif e‌fot‌Yk nkhjj k‌dD}ll khwwk Ro‌ahfNt ,UfFk.

k‌d‌D}l‌lj‌j‌d‌ Fthz‌lkhf‌fy‌ (Quantization)

,awifa‌y f‌ilffgngWk r‌Wk k‌dD}ll kj‌gG vttsT? vyfluhd‌d k‌dD}ll kj‌gG –e vdTk GNuhllhd‌d k‌dD}ll kj‌gG +e vdTk MaTfs njs‌TggLjJf‌dwd. ,qF e vdgJjhd k‌dD}lljj‌d mbggil kj‌gG. vejnthU nghUs‌y css k‌dD}lljj‌d kj‌gGk ,ej mbggil kj‌gg‌d KO klqfhfNt ,UfFk.

$$q = ne$$

,qF n vdgJ xU KOntz (0, ±1, ±2, ±3, ±4.....)., JNt k‌dD}lljj‌d Fthzlkhffy vdggLk. e ,d kj‌gG 1.6×10^{-19}C vdgij Gfongww Mat‌d %yk ,uhghl k‌yy‌fd fzlw‌ejhh. vyfluhd‌d k‌dD}ll kj‌gG = 1.6×10^{-19} C kwWk GNuhllhd‌d k‌dD}ll kj‌gG = + 1.6×10^{-19} C.

fzzhbj jznlhdW glLjJz‌ahy NjaffggLkNghJ ,lk ngaUk k‌dJfsfs‌d vzz‌fif (n) k‌fgngh‌ajhf ,UfFk (nghJthf 10^{10}). vdNt› eilKiwa‌y ehk fhZk nghUlfSfF k‌dD}lljj‌d Fthzlkhffy Fw‌gg‌ljjff gqF tf‌ggj‌yiy. MdNt› k‌dD}lljijj (g‌h‌Te‌iyaww njhlh kj‌gGilajhff fUjyhk. Mdhy (fz ZfFg Gydhfhj) Ezz‌a e‌iya‌y k‌dD}lljj‌d Fthzlkhffy Kffa gqif tf‌ff‌wJ.

xU $Y}k k‌dD}ll kj‌gGila vj‌h k‌dJfs‌Yss vyfluhdfs‌d vzz‌fifiaf fzff‌Lf.

jhT:
k‌dD}lljj‌d Fthzlkhffy (gzg‌d) gb›

$$q = ne$$

,qF q = 1 C. vdNt› ,j‌Yss vyfluhdfs‌d vzz‌fif›

$$n = \frac{q}{e} = \frac{1}{1.6' 10^{-19}} = 6.25' 10^{18} \text{ vyfluhdfs}$$

$Y}k‌ t‌j‌j‌:

ntww‌l ntsa‌y (free space) e‌iyahf css ,U Gss‌ k‌dJfsfSfF ,ilNa fhzggLk t‌irffhd Nfhitia 1786 Mk Mzby $Y}k vdgth jUt‌jjhh.

ntwwplljpy r njhiytpy gphpjJ itffgglLss ,U epiyahfTss Gsspkpd Jfsfisf fUJNthk. mtwwpd kpdD}llqfs KiwNa q_1 kwWk q_2MFk. $Y}k tpjpggb› Gsspkpd Jfs›q_2 tpd kJ Gsspkpd Jfs q_1 nraygLjJk tpirahdJ gpdtUkhW vOjggLfpwJ.

$$\vec{F}_{21}=k\frac{q_1q_2}{r^2}\hat{r}_{12}$$

,qF r_{12}vdgJ q_1,ypUeJ $q_2$it Nehffp tiuaggLk XuyF ntflh kwWk k vdgJ jfT khwpyp.

$Y}k tpjpapd; Kf;fpa ,aygfs;

epiykpd tpirahdJ Gsspkpd Jfsfspd kpdD}ll kjpggpd ngUffwgyDfF Nehjjftpyk mtwwpwF ,ilNa css njhiytpd ,UkbfF vjphjjftpyk ,UfFk.

$q_2$kpdJfspd kJ $q_1$kpdJfs nrYjJk tpir mtwiw ,izfFk Nfhlbd jpirapNyNa ,UfFk. ,jpy $\hat{r}_{12}$vdw XuyF ntfluhdJ kpdJfs $q_1$ypUeJ $q_2$it Nehffpa jpirapypUfFk mNjNghy›q_1,d kJ $q_2$nrYjJk tpir -$\hat{r}_{12}$jpirapypUfFk (mjhtJ d $\hat{r}_{12}$jpirfF vjphjjpirapy)

SI myF Kiwapy›k = $\frac{1}{4pe_o}$ kwWk k d kjpgG 9 × 10^9 N m^2 C^{-2}vdWk fzlwpaggLsJ. ,qF $e_o$vdgJ ntwwplljpd tpLjpwd (Permittivity of free space) vdggLk. mjd kjpgG

xU $Y}k kpdD}ll kjpgG nfhzl xU kllh ,ilntspapy itffgglLss ,U kpdJfsfSfF ,ilNa nraygLk tpirapd kjpgigg gpdtUkhW fzffplyhk.

$$\left|\vec{F}\right|=\frac{9\acute{}10^9\acute{}1\acute{}1}{1^2}=9\acute{}10^9N$$

,J kpfgnghpa tpirahFk. fplljjll xU kpyypad ld epiw nfhzl nghUspd vilfFr rkkhFk. eilKiwapy 1 $Y}k msT kpdD}llk nfhzl kpdJfsfis ehk vjphnfhstNj ,yiy. ek mdwhl thotpy epfOk ngUkghyhd kpdepfoTfspy µC (ikfNuh $Y}k) kwWk nC (NehNdh $Y}k) mstpyhd kpdD}llqfs nfhzl kpdJfsfNs ,lk ngWfpdwd.

SI myF Kiwapy› ntwwplljpwfhd $Y}k tpjpapd tbtk $\vec{F}_{21}=\frac{1}{4pe_o}\frac{q_1q_2}{r^2}\hat{r}_{12}$ tpLjpwd *e*kjpgGila NtnwhU Clfjjpy itffgglLss Gsspkpd JfsfSfF ,ilNa nraygLk tpir $\vec{F}_{21}=\frac{1}{4pe}\frac{q_1q_2}{r^2}\hat{r}_{12}$

Mdhy $e>e_o$vdNt› ntwwplljpy css Gsspkpd JfsfSfF ,ilapyhd tpiria tpl gpw Clfqfspy nraygLk tpir Fiwthf ,UfFk. NkYk xU Clfjjpd rhhG tpLjpwid (Relative permittivity) ehk gpdtUkhW tiuaWffyhk. $e_r=\frac{e}{e_o}$. ntwwplk kwWk fhwwy $e_r=1$kww ClfqfSfF $e_r>1$.

$Y}k tpj epA+lldpd <hgG tpjapd mikgigNa nfhzLssJ. ,ttpuzbYk tpirahdJ› ,iljnjhiytpd ,UkbfF vjphjjfty cssthW mikeJssd. epiykpd tpir› Gsspkd Jfsfspy cssk pdD}llqfspd ngUffYfF Nehjjftpyk<hgG tpir Gsspepiwfspd ngUffYfF Nehjjftpyk mikeJssd. Mdhy› ,twwpwfpilNa rpy Kffpa NtWghLfSk cssd.

,U epiwfSfF ,ilNaahd <hgG tpir vgNghJk ftUk tpirahfNt cssJ. $Y}k tpirNah› kpdJfsfspd ,ayig nghUjJ ftUk tpirahfNth tpyfF tpirahfNth ,Uffpdw J.

<hggpay khwpypapd kjpgG G = 6.626 × 10^{-11} Nm^2kg^{-2} Mdhy› $Y}k tpjpapy css khwpypapd kjpgG k = 9 × 10^9 N m^2 C^{-2}. k d kjpgG G I tpl kpfTk mjpfkhjyhy epiw Fiwthd nghUsfSfF <hgG tpiriaf fhlbYk epiykpd tpirapd kjpgG kpfTk mjpfkhfNt ,UfFk.

,U epiwfSfF ,ilapy css <hgG tpir mJ itffgglbUfFk Clfjijr rhhejjyy. vLjJffhllhf› fhwwpNyh myyJ ehpNyh›vjpy itffgglbUejhYk ,U 1 kg epiwfSff pilNa nraygLk <hgG tpirapd kjpgG khwhJ. Mdhy› ,U kpdJfsfSfF ,ilNa nraygLk epiykpd tpirNah mit itffgglLss Clfjjpd jdikia rhheJ ,UfFk.

epiwfs epiyahf ,UejhYk ,affjjpypUejhYk <hgg tpir xdwhfNt ,UfFk. Mdhy› kpdJfsfs ,aqFkNghNjh $Y}k tpirAld NrheJ kwnwhU tpirAk (yhd] tpir) nrayglj JtqFk.

kpdJfs q_1,d kJ kpdJfs $q_2$nrYjJk tpir

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_\circ}\frac{q_1 q_2}{r^2}\hat{r}_{21}$$

,qF $\$_{21}$vdgJ $q_2$tpypUeJ q_1l Nehffpa jpirapYss XuyF ntfluhFk. Mdhy› vdg gpujpapllhy› $\$_{21} = -\$_{12}$

$$\overline{F}_{12} = \frac{1}{4pe_o}\frac{q_1 q_2}{r^2}(-\$_{12}) = -\frac{1}{4pe_o}\frac{q_1 q_2}{r^2}(\$_{12})$$

(myyJ) $\overline{F}_{12} = \overline{F}_{21}$

vdNt epiy kpd tpir epA+lldpd %dwhk tpjpfFlgllJ.

$Y}k tpj Gsspkd Jfsfsfs klLNk nghUeJk. Mdhy› Gsspkd Jfs vdgJ xU fUjjhffk klLNk. eilKiwapy rhjjpakpyiy. kpdJfsfSfF ,ilNa css njhiyit xggpLkNghJ mtwwpd cUt msT kpfTk rpwpajhf ,Uejhy› $Y}k tpjpia ehk gadgLjjyhk. ,dDk nrhyygNghdhy $Y}k jd Nrhjidapy› KWfFjjuhR (Torsion balance) xdwpy itffggll kpdD}llk ngww ,U Nfhsqfisg Gsspkd Jfsfshff fUjpNa mth jk tpjpiaf fzlwpejhh. mej Matpy› Nfhsqfspd Muqfis tpl mtwwpwfpilNaahd njhiyT kpf mjpfk.

vLjJf fhl L

gljjpy ,U Gsspkd Jfsfs $q_1$kwWk $q_2$epiyahf cssd.

mit 1 m ,ilntspapy gphpjJ itffgglLssd. gpdtUk NehTfSfF mtwWfF ,ilNa nraygLk tpiria fzffpLf.

1. q_1 = +2 µC kwWk q_2 = +3 µC

2. $q_1 = +2\ \mu C$ kwWk $q_2 = -3\ \mu C$
3. $q_1 = +2\ \mu C$ kwWk $q_2 = -3\ \mu C$ ehy; $(e_r = 80)$ i t f fggLk NghJ

jhT:

$q_1 = +2\ \mu C, q_2 = +3\ \mu C, r = 1m.$, qF ,uz LNk Neh kdJfsfs. Mjyhy›, twwwF , ilNa tyfF tir nraygLk

kdJfs q_1My kdJfs q_2 c zUk tir

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{12}$$

, qF $\hat{r}_{12}$ vdgJ q_1 yUeJ q_2 l Nehffa jiraYss XuyF ntflh q_1 fF tyJ gffjjy q_2 cssjhy›

$$\hat{r}_{12} = \hat{i}$$ vdNt

$$\vec{F}_{21} = \frac{9 \times 10^9 \times 2 \times 10^{-6} \times 3 \times 10^{-6}}{1^2}\hat{i}$$

$$\left[\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\right]$$

$$= 54 \times 10^{-3}\ N\hat{i}$$

eAlldd %dwhk tjggb› kdJfs q_2 My q_1 c zUk tir $\vec{F}_{12} = -\vec{F}_{21}$

vdNt $\vec{F}_{12} = -54 \times 10^{-3}\ N\hat{i}$

$\vec{F}_{21}$ kwWk $\vec{F}_{12}$ Mfatwwd jirfs gljjy (NehT (m) fhllgglLssJ.

$q_1 = +2\ C, q_2 = -3\ \mu C, r = 1m.$, it Ntwd kdJfsfshjshy , twwwfilNa ftUk tir nraygLk. kdJfs q_1My q_2 c zUk tir

$$\vec{F}_{21} = \frac{9 \times 10^9 \times \left(2 \times 10^{-6}\right) \times \left(-3 \times 10^{-6}\right)}{1^2}\hat{r}_{12}$$

$= -54 \times 10^{-3}\ N\hat{i}$ (/ , qF $\hat{r}_{12} = \hat{i}$)

vdNt› kdJfs q_2 MdJ q_1 l Nehffa jiraiy (mjhtJ vjufFw; x jiraiy) xU ftUk tiria c zUk.

eAlldd %dwhk tjggb› kdJfs q_2 My q_1 c zUk tir

$$\vec{F}_{12} = -\vec{F}_{21}$$

mjhtJ $\vec{F}_{12} = 54 \times 10^{-3} N\hat{i}$

$\vec{F}_{21}$ kwWk $\vec{F}_{12}$ Mfa tirfsd jir gljjy (NeuT - M) fhllgglLssJ.

(,) ,U kdJfsfSk eUfFs itffgglhy q_2 c zUk tir

$$\vec{F}_{21}^{W} = \frac{1}{4pe}\frac{q_1 q_2}{r^2}\hat{r}_{12}$$

Mdhy $e = e_r e_0$

$$\vec{F}_{21}^{W} = \frac{1}{4pe_r e_0}\frac{q_1 q_2}{r^2}\hat{r}_{12} = \frac{\vec{F}_{21}}{e_r}$$

vdNt

$$\vec{F}_{21}^{W} = \frac{54' 10^3 N}{80}\hat{i} = -0.675' 10^{-3} N\hat{i}$$

,U kdJfsfSff ilNa ntwwljjy nraygLk tiria tl mit eUfFs itffggLk NghJ nraygLk tir $\frac{1}{80}$ gqfhff FiweJssijf ftdffTk. rhjhuz cgig (NaCl) euy ,LkNghJ› eud mjf kjgGila rhuG tLjwdhy ($e_r = 80$) Na kwWk Clmadf SfF ,ilNa eyTk eiykd tir FiweJ tLfwJ. ,jdhy jhd eu xU rwej fiugghdhf cssJ.

vLj;Jf;fhl;L:

xtnthdWk 1g eiwAila rwa cUtsT nfhzl› ,U xNu khjuahd Nfhsqfs rkeiyay cssthW› gljjy fhllggILssd. E}yd esk 10 cm kwWk nrqFjJj jirAld E}y cUthfFk Nfhzk 7° vdy Nfhsk xtnthdwYk css kdD}lljijf fzffLf. ($g = 10\ ms^{-2}$ vd vLjJfnfhsf)

jluT

Nfhsqfs ,uzLk kdD}llk mwwitahf ,Uejhy› mit njhqftlggLkNghJ mtwWfF ,ilNa cUthFk Nfhzk 0° Mf ,UfFk. Mdhy mit Neu kdD}llk ngww Nfhsqfs Mjyhy› mtwWffilNa tyfF nraygIL› nrqFjJ jirfF 7° Nfhzjjy mit rkeiyfF tUfdwd. rkeiyay xtnthU NfhsKk czUk efu tir RoahFk. mtwWs VNjDk xU Nfhsjjwfhd jdjj nghUs tirgglijij ehk tiueJ› nrqFjJ kwWk filkllj jirfsy eAlld ,uzlhk tjpiag gadgLjJNthk

NeufFw x– jiray Nfhsjjd efu KLffk Ro.

eAlld ,uzlhk tjggb $\left(\vec{F}_{tot} = m\vec{a}\right)$,

$T\sin\theta\hat{i} - F_e\hat{i} = 0$

$T\sin\theta = F_e$ (1)

,qF T vdgJ E}ydhy Nfhsjjd kJ nrYjjggLk ,Otir kwWk F_e vdgJ ,U NfhsqfSfF ,ilayhd eiykd tir.

y- jiray Yk $l› Nfhsjjd efu KLffk Ro. vdNt

$T\cos\theta\hat{j} - mg\hat{j} = 0$

vdNt› $T\cos\theta = mg$.

rkdghL (1) l (2) My tFff›

$$\tan\theta = \frac{F_e}{mg}$$

,U Nfhsqf Sk rkkdD}llk ngwWs sjhy› epiykd tpiradd vzkjpgG

$$F_e = k\frac{q^2}{r^2} \text{ , qF } k = \frac{1}{4pe_0}$$

NkYk r = 2 a = 2L Sinθ› rkdghL (3)y gpujpapl

$$\tan q = k\frac{q^2}{mg(2L\sin q)^2} \qquad (4)$$

rkdghL (4) l khwwpaikff

$$q = 2L\sin q\sqrt{\frac{mg\tan q}{k}}$$

$$= 2\acute{}\ 0.1\acute{}\ \sin 7°\acute{}\ \sqrt{\frac{10^{-3}\acute{}\ 10\acute{}\ \tan 7°}{9\acute{}\ 10^9}}$$

q = 8.9 × 10^{-9} C = 8.9 nC

vLjJfifhlL:

i`bu[d mZtpy css GNuhllhDfFk vyfluhDfFk ,ilNaahd epiykpd tpir kwWk <ugG tpiriaf fzffpLf. mtwwpd ,iljnjhiyT 5.3 × 10^{-11} vyfluhd kwWk GNuhllhd ,itapuzbwFk kpdD}ll kjpgG 1.6 × 10^{-19} C. vyfluhdpd epiw m_e = 9.1 × 10^{-31} kg kwWk GNuhllhdpd epiw m_p = 1.6 × 10^{-27} kg.

jpuT

GNuhllhDk vyfluhDk xdiwnahdW ftUfpdwd. ,ttpU kpdJfsfSfFk ,ilNaahd epiykpd tpiradd vzkjpgG

$$F_e = \frac{ke^2}{r^2} = \frac{9\acute{}\ 10^9\acute{}\ (1.6\acute{}\ 10^{-19})^2}{(5.3\acute{}\ 10^{-11})^2}$$

$$= \frac{9\acute{}\ 2.56}{28.09}\acute{}\ 10^{-7} = 8.2\acute{}\ 10^{-8}\text{N}$$

GNuhllhd kwWk vyfluhDfF ,ilNaahd Gtpaugg tpirAk ftutpirNa. ,ttpU JfsfSfFk ,ilNa epyTk <ugG tpiradd vzkjpgG

$$F_G = \frac{Gm_em_p}{r^2}$$

$$= \frac{6.67\acute{}\ 10^{-11}\acute{}\ 9.1\acute{}\ 10^{-31}\acute{}\ 1.6\acute{}\ 10^{-27}}{(5.3\acute{}\ 10^{-11})^2}$$

$$= \frac{97.11}{28.09}\acute{}\ 10^{-47} = 3.4\acute{}\ 10^{-47}\text{N}$$

,ttpU tpirfSfFkhd tpfpjk

$$\frac{F_e}{F_G} = \frac{8.2 \times 10^{-8}}{3.4 \times 10^{-47}} = 2.41 \times 10^{39}$$

$F_e \approx 10^{39} F_G$ vdgijf ftdpffTk.

GNuhllhDfFk vyfluhDfFk ,ilNaahd epiykpd tpirahdJ mtwWfppilNa epyTk <hgG tpiriatpl gy klqF kpfgnghpaJ. vdNt› rpwpa epiw nfhzl nghUsfs kwWk mZepiy msTfs (Atomic domain) csspll gy #oepiyfspy epiykpd tpiria xggpLifapy <hgG tpir Gwffzpffjjffnj. ,jdhy jhd› kpdD}llkww rpW fhfpjjJzL xdW Gtpapd <hgG tpirapdhy ftuggllhYk mij tpl mjpf typikAld kpdD}llk ngww rgG xdwpdhy (mffhfpjj Jzil) ftu Kbfpwj.

NkwnghUeJjy; jj;Jtk;:

,U Gsspkpd JfsfSfF ,ilNa VwgLk ,iltpidia $Y}k tpjp tpsfFfpwJ. ,uzbwF Nkwgll kpdJfsfs ,Uejhy› xtnthU kpdJfspd kJk kww midjJ kpdJfsfSk nrYjJk tpiriaf fzffpl NtzLk. ,jjifa #oepiyfSfF $Y}k tpjapdhy klLNk tpir fhz ,ayhJ. gy kpdJfs mikgGfspy VwgLk ,iltpidfisg gwwp NkwnghUeJjy jjJtk tpsfFfpwJ.
NkwnghUeJjy jjJtjjpd gb› xU Fwpggpll kpdJfs kJ nraygLk nkhjj tpirahdJ kww midjJ kpdJfsfs mjd kJ nraygLjJk tpirfspd ntflh $LjYfFr rkkhFk.

q_1, q_2, q_3,.... q_nMfpa kpdD}ll kjpgGfisAila n kpdJfsfis csslffpa mikgG xdiwf fUJf. q_1 d kJ $q_2$nrYjJk tpir

$$\vec{F}_{12} = k\frac{q_1 q_3}{r_{21}^2}\hat{r}_{21}$$

,qF vdgJ tpypUeJ l ,izfFk Nfhlbd jpirapy mikAk XuyF ntflh kwWk vdgJ mit ,uzbwFkhd ,iljnjhiyT MFk. ,ttpU kpdJfsfSfF ,ilNaahd tpir› Rwwp mikeJss kww kpdJfsfshy khwwggLtjpyiy.

q_1d kJ $q_3$nrYjJk tpir

$$\vec{F}_{13} = k\frac{q_1 q_3}{r_{31}^2}\hat{r}_{31}$$

,NjNghy q_1d kJ kww midjJ kpdJfsfshYk nrYjjggLk nkhjj epiykpd tpir

$$\vec{F}_{1}^{tot} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + ...\vec{F}_{1n}$$

$$\vec{F}_{1}^{tot} = k\left\{\frac{q_1 q_2}{r_{21}^2}\hat{r}_{21} + \frac{q_1 q_3}{r_{31}^2}\hat{r}_{31} + \frac{q_1 q_4}{r_{41}^2}\hat{r}_{41} + ...+ \frac{q_1 q_n}{r_{n1}^2}\hat{r}_{n1}\right\}$$

,U kpdJfsfis tpl mjpf vzzpfifapy csskpdJfs mikgGfspy› NkwnghUeJjy jjJtjijg gadgLjjhky $Y}k tpjp KOik ngwhJ. NkwnghUeJjy jjJtk kwWk $Y}k tpjp Mfpait epiy kpddpaypd mbggilj jjJtqfshFk. epiy kpddpaypy fhzggLk midjJ epfoTfisAk ,ttpuzL jjJtqfs tpsfFfpdwd. MdhYk ,ttpuzL jjJtqfisAk xdwpypUeJ kwnwhdiwj jUtpff ,ayhJ.

vLj;Jf;fhl;L:

Muk 1m nfhzl tlljjpYss ehdF Gsspfspy ehdF rkkhd kpdD}llk nfhzl kpdJfsfs q_1, q_2, q_3kwWk $q_4 = q = +1\,\mu C$ itffgglLssd kpdJfs q_1d kJ kww midjJ kpdJfsfshYk nrYjjggLk nkhjj tpiriaf fhzffpLf.

jhT:

NkwnghUeJjy jjJtjjpd gb q_1 d kJ nrYjjggLk nkhjj epiykpd tpirahdJ kww kpdJfsfshy mjd kJ nrYjjggLk jdpjjdp tpirfspd ntflh $LjYfFr rkk. q_1d kJ nraygLk tpir xtnthdwpd jpirAk gpdtUk gljjpy fhllgglLssJ.

$$\vec{F}_1^{tot} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14}$$

q_2 kwWk q_4Mfpa kpdJfsfs q_1 ypUeJ rk njhiytpy cssd. vdNt› jpirapdhy

NtWgllhYk $\vec{F}_{12}$kwWk $\vec{F}_{14}$ tpirfspd vzkjpgG rkkhFk. ,jdhy jhd mtwiwf Fwpggplg gadgLjjpa ntflhfs rkesKld tiuagglLssd. Mdhy q_2 kwWk q_1 Mfpatwiwf fhlbYk mjpf njhiytpy kpdJfs q_3 cssJ. njhiyT $bdhy epiykpd tpirapd typik FiwAk. Mjyhy› tpirfs $\vec{F}_{12}$kwWk $\vec{F}_{14}$Mfpatwiw tpl $\vec{F}_{13}$d vzkjpgG FiwT. ,jdhy jhd tpirfs $\vec{F}_{12}$kwWk $\vec{F}_{14}$Mfpatwwpd esjij tpl tpir $\vec{F}_{13}$d esk Fiwthf tiuagglLssJ.

gljjpypUeJ $r_{21} = \sqrt{2}m = r_{41}$ kwWk $r_{31} = 2m$ tpirfspd vzkjpgG

$$F_{13} = \frac{kq^2}{r_{31}^2} = \frac{9 \times 10^9 \times 10^{-12}}{4}$$

$F_{13} = 2.25 \times 10^{-3}$ N

$$F_{12} = \frac{kq^2}{r_{21}^2} = \frac{9 \times 10^9 \times 10^{-12}}{2}$$

$= 4.5 \times 10^{-3}$ N

gljjpypUeJ $\theta = 45°$,ej tpirfs mtwwpd ntflh $Wfisf nfhzL gpdtUkhW vOjggLfpwJ.

$$\vec{F}_{12} = F_{12}\cos\theta\hat{i} - F_{12}\sin\theta\hat{j}$$

$$= 4.5 \times 10^{-3} \times \frac{1}{\sqrt{2}}\hat{i} - 4.5 \times 10^{-3} \times \frac{1}{\sqrt{2}}\hat{j}$$

$$\vec{F}_{13} = F_{13}\hat{i} = 2.25 \times 10^{-3} N\hat{i}$$

$$\vec{F}_{14} = F_{14}\cos\theta\hat{i} + F_{14}\sin\theta\hat{j}$$

$$= 4.5 \times 10^{-3} \times \frac{1}{\sqrt{2}}\hat{i} + 4.5 \times 10^{-3} \times \frac{1}{\sqrt{2}}\hat{j}$$

vdNt q_1 d kJ nraygLk nkhjj tpir

$$\vec{F}_1^{tot} = \left(F_{12}\cos\theta\hat{i} - F_{12}\sin\theta\hat{j}\right) + F_{13}\hat{i}$$

$$+ \left(F_{14}\cos\theta\hat{i} - F_{14}\sin\theta\hat{j}\right)$$

$$\vec{F}_1^{tot} \left(F_{12}\cos\theta - F_{13} + F_{14}\cos\theta\right)\hat{i}$$

$$+ \left(-F_{12}\cos\theta + F_{14}\sin\theta\right)\hat{j}$$

$F_{12} = F_{14}$Mjyhy›$\hat{j}$ jpirf$W Ropahfk.

vdNt›

$$\vec{F}_1^{tot} = \left(F_{12}\cos q + F_{13} + F_{14}\cos q\right)\hat{i}$$

,rrkdghlby kjpgGfisg gpujpalš

$$= = \left(\frac{4.5}{\sqrt{2}} + 2.25 + \frac{4.5}{\sqrt{2}}\right)\hat{i} = \left(4.5\sqrt{2} + 2.25\right)\hat{i}$$

$$\vec{F}_1^{tot} = 8.61\times 10^{-3} N\hat{i}$$

njhFgad tpirahdJ NehfFwp x- mrR jpiraply mikfpwJ.

kpdGyk; kwWk; kpdGyf; NfhLfs;

kpdGyk;

,U kpdJfsfSfF ,ilNa epfOk ,iltpid $Y}k tpjpadhy ngwggLfpwJ. ,ej ,iltpid vtthW cUthfpwJ? ntspggugpy (space) xU Gsspaply itffgglLss Gsspkpdjfs xdiwf fUJNthk. mjpypUeJ rpwJ njhiytpy ,dndhU Gsspkpdjfis itjjhy mJ ftUk tpir myyJ tpyfF tpiria czUk. ,ij njhiytpy epfOk tpirrnray (action – at – a distance) vdgh. Mdhy rpwJ njhiytpy itffggLfpdw ,uzlhtJ kpdJfs› Kjy kpdJfspd ,Ugig vtthW mwpeJ nfhsfpwJ? ,ejf Nfstpffhd tpilia mspffNt ikfNfy ghuNl kpdGyk vdw fUjjpaiy mwpKfk nrajhh.

ghuNltpd fUjJggb› gpugQrjjpYss xtnthU kpdJfSk mjidr Rwwp xU kpdGyjij cUthfFfpdwJ. ,ej kpdGyjjpy ,dndhU kpdJfisf nfhzL tUkNghJ› Kjy kpdGyjJld mJ ,iltpid Ghptjhy xU tpiria czhfpwJ. ,NjNghy›<hgGgGyk vdw fUjjpaiy mwpKfggLjjpa NghJk›

mJ ,U epiwfSffpilNa nraygLk ,iltpidNa vdW tpthpjjij epidtpy nfhssTk kpdtpir kwWk <hgGtpir Mfpa ,uzLNk njhlh tpirfs. Mjyhy njhiytpy epfOk tpirrnrayfis tpsff Gyk vdw fUjjpay NjitggLfpwJ.

Gwntspapy xU Gsspapy itffgglLss q vdw Gsspkpdjfs xdiwf fUJf. mjpypUeJ r njhiytpy css P vdw Gsspapy q0vdw ,dndhU kpdJfs (Nrhjid kpdJfs) itffggLfpwJ. q My Nrhjid kpdJfs q0 czUk epiykpd tpir $Y}k tpjpadhy ngwggLfpwJ.

$$\vec{F} = \frac{kqq_0}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r^2}\hat{r} \quad \text{இங்கு} \quad k = \frac{1}{4\pi\varepsilon_0}$$

jdidr Rwwp mikeJss ntspggugpy kpdJfs q MdJ xU kpdGyjij cUthfFfpwJ. q vdw GsspkpdjfspypUeJ njhiytpYss Gsspkpdjfs P ,y itffggLk XuyF kpdD}llk nfhzl kpdJfshy czuggLk tpirNa mgGsspkpdjfs P ,y itffggLk XuyF kpdD}llk nfhzl kpdJfshy czuggLk tpirNa mgGsspkpdjfs P ,y css kpdGyjjpd kjpgghFk. ,ijNa ehk gpdtUkhW vOjyhk.

$$\vec{E} = \frac{\vec{F}}{q_0} = \frac{kq}{r^2}\hat{r} = \frac{1}{4pe_0}\frac{q}{r^2}\hat{r}$$

,qF $\hat{r}$ vdgJ q tpypUeJ ehk vLjJfnfhzl Gsspkpdjfs PfF tiuaggLk XuyF ntfluhFk. kpdGyk xU ntflu msT› NkYk mjd SI myF epAlld / $Y}k (NC^{-1}) MFk.

kpdGyjjpd; Kfpfa gzGfs;

i) kdJfs q Neu kdD}llk (+) nfhzljhf ,Uejhy› kdJfsypUeJ ntspNehffpa jpirapy kdGyk ,UfFk. q Vjphkd D}llk (-) nfhzljhf ,Uejhy csNehffpa jpirapy kdGyk ,UfFk.

ii) P vdw xU Gsspapy kdGyk $\vec{E}$ vdpy› mgGsspapy itffggLk Nrhjid kdJfs q_0 My czuggLk tpir.

$$\vec{F} = q_0 \vec{E}$$

,JNt› kdGyf fUjjpaypd %ykhf $Y}k tpiriag ngWk Kiw.

i) kdGykhdJ Nrhjid kdJfspd kdD}llk q_0 lr rhuejjyy vdgijAk %y kdJfspd (Source charge) kdD}ll kjpgG q l klLNk rhuejJ vdgijAk rkdghL (1.4)d %ykhd mwpayhk.

ii) kdGyk xU ntflu msT vdgjhy mjwF jdpjjnthU jpirAk vzkjpgGk ntspapYss xtnthU Gsspapyk ,UfFk. kdJfSfFk GsspfFk ,ilNa css njhiyT (r)

mjpfupjjhy kdGyjjpd vzkjpgG FiwAk vdgij rkdghL. kdGy %yjjpwF mUfpy GsspPmikeJssjhy mqF

kdGyjjpd typik myyJ vzkjpgG kww Gsspfs Q kwWk R l tpl mjpfkhf cssJ.

iv) Nrhjid kdJfs (q_0) itffggLkNghJ %y kdJfs efuhky ,Uggjwfhf mjd kdD}ll kjpgG q_0 kpfTk rpwpajhf vLjJf nfhssggLfpwJ myyJ %y kdJfspd kdGyjijg ghjpffhjthW ,Uggjwfhf Nrhjid kdJfs kpfrrpwpa kdD}ll kjpgGilajhf vLjJfnfhssggLfpwJ.

v) rkdghL (1.4) Gsspkd JfsfSfF klLNk nghUeJk. kdJfsfspd njhlu gutyfSfFk› tukgpwFlgll kdD}ll msT nfhzl kdJfs gutyfSfFk njhifaply Kiwfisg gadgLjj NtzLk. ,twiwg gpddu ghugNghk. ,UggpDk› tukgpwFlgll kdD}ll msT nfhzl kdJfsplkpUeJ Nrhjidg Gsspntf njhiytpy cssNghJ› mjJfshy cUthffggLk kdGyjjpwfhd Njhuhakhd mstlhf ,rrkdghlilg gadgLjjyhk. Gtpapd kJ #upad VwgLjJk <ugGg Gyjijf fzffpLkNghJk› Gtpia xU Gsspepiwahff fUjpaij epidT nfhssTk

vi) kdGyqfspy ,U tiffs cssd: ruhd (khwhj) kdGyk kwWk ruww kdGyk. Gwntspapy (space) css midjJ Gsspfspyk xNu jpirAld khwhj vzkjpgGk nfhzbUejhy mJ ruhd kdGyk (uniform electric field) vdggLk. Gwntspapy nttNtW Gsspfspy nttNtW jpirfs myyJ nttNtW vzkjpgGfs myyJ ,ttpuzLNk nfhzbUejhy mJ ruww kdGykhFk. Gsspkd JfsxdwpdhyVwgLk kdGyk ruww kdGyNk. mjd ruww jdik jpirapYk cssJ› vz kjpggpYk cssJ – mjd jpir MugNghffpy ntspNehffpathW (myyJ csNehffpathW) mikfpwJ. NkYk njhiyT mjpfupffkNghJ› mjd vz kjpgGk khWgLfpwJ.

vLjJf;fhl;L

gpdtUk ,U NeuTfSfF P kwWk Q Gsspfspy kdGyjijf fzffpLf.

(m) MjgGsspay itffgglLss +1µC kdD}llk nfhzl Gssp Neu kdJfshy cUthFk kdGyk.

(M) MjgGsspay itffgglLss -2 µC kdD}llk nfhzl Gssp vju kdJfshy cUthFk kdGyk

jµT
NeuT (m)

Gssp P apy kdGyjjpd vzkjpgG

$$E_P = \frac{1}{4pe_0}\frac{q}{r^2} = \frac{9' 10^9 ' 1' 10^{-6}}{4}$$
$$= 2.25' 10^3 NC^{-1}$$

,qF %y kdJfs Neu kdD}llk nfhzljhf ,Uggjhy; mjpypUeJ ntspNehffpa jpirapy kdGyk FwpffggLfpdwJ. vdNt; Gssp P ,y kdGyk

uuu
$$E_P = 2.25' 10^3 NC^{-1}\hat{i}$$

புள்ளி Q ல்

$$\left|\vec{E}_Q\right| = \frac{9\times10^9\times1\times10^{-6}}{16} = 0.56\times10^3\, NC^{-1}$$

எனவே $\vec{E}_Q = 0.56\times10^3\,\hat{j}$

Gssp Py kdGyjjpd vzkjpgG

$$\left|\vec{E}_P\right| = \frac{kq}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} = \frac{9\times10^9\times2\times10^{-6}}{4}$$

$$= 4.5\times10^3\ \mathrm{N\,C^{-1}}$$

,qF %y kdJfs vjph kdD}llk nfhzljhf ,Uggjhy; mij Nehffpa jpirapy kdGyk FwpffggLfpdwJ. vdNt; Gssp Py kdGyk

$$\vec{E}_p = -4.5\times10^3\,\hat{i}\;NC^{-1}$$

புள்ளி Q ல் $\left|\vec{E}_Q\right| = \frac{9\times10^9\times2\times10^{-6}}{36}$

$= 0.5 \times 10^3\ \mathrm{N\,C^{-1}}$

மேலும் $\vec{E}_Q = 0.5\times10^3\,NC^{-1}\hat{i}$

புள்ளி Q ல் மின்புலம் நேர் x – அச்சின் திசையில் உள்ளது.

Gs;s kd;Jfs;fshyhd mikgg;d; kdGyk;

Gwnts;ay (space) gy Gss; kdJfsfs gut;Ass mikgG xdiwf fUJNthk. ,ejg Gss; kdJfsfs;d mikgg;dhy xU Gss;ay cUthFk nkhjj kdGyjijf fzff;LtjwF NkwnghUeJjy jjJtjijg gadgLjJf;Nwhk. ,ttikgg;y VNjDk xU Gss;ay fhzggLk njhFgad kdGykhdJ xtnthU kdJfSk mgGss;ay cUthfFk kdGyqfs;d ntflh $LjYfFr rkk. ,JNt kdGyqfs;d NkwnghUeJjy vdggLk.

nts;ggugg;y gyNtW Gss;fs;y mikeJss q_1, q_2, q_3.....q_nMf;a Gss; kdJfsfs;d mikgigf fUJNthk. ,ttidjJ kdJfsfshYk VNjhnthU Gss; (P) ay cUthFk nkhjj kdGyk

$$\vec{E}_{tot} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \ldots\ldots + \vec{E}_n \quad (1.6)$$

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\left\{\frac{q_1}{r_{1P}^2}\hat{r}_{1P} + \frac{q_2}{r_{2P}^2}\hat{r}_{2P} + \frac{q_3}{r_{3P}^2}\hat{r}_{3P} + \ldots \right.$$
$$\left. \ldots + \frac{q_n}{r_{nP}^2}\hat{r}_{nP}\right\} \quad (1.7)$$

,qF q_1, q_2, q_3..... q_nMf;a kdJfsfSfFk Gss; P fFk ,ilNaAss njhiyTfis KiwNa r_{1p}, r_{2p}, r_{3p}.....r_{np} vdf. NkYk $\hat{r}_{1p}, \hat{r}_{2p}, \hat{r}_{3p}$.....$\hat{r}_{np}$ Mf;ad KiwNa q_1, q_2, q_3..... $q_n$kdJfsfs;y ,UeJ mgGss;fF tiuaggll xuyF ntflhfshFk.

rkdghL g;dtUkhW vOjyhk.

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\left(\frac{q_i}{r_{iP}^2}\hat{r}_{iP}\right)$$

vLjJffhllhf q_1,q_2,q_3,Mfpa %dW Gsspkpd Jfsfshy xU Gsspy cUthFk njhFgad kpdGyk

Fwpggpll Gsspy (P) apypUeJ kpdJfspd rhhGj njhiyTfisg (relative disances) nghWjNj kpdGy ntflhfspd rhhG esqfSk (relative length) cssijf ftdpffTk.

gljjpy nfhLffgglLss Gsspy kpdJfs mikgigf fUjTk› Gsspy A y cUthFk kpdGyjijf fzffpLf. mgGsspapy vyfluhd xdW itffgglhy› mJ milAk KLffk vttsT? (vyfluhdpd epiw = 9.1 × 10^{-31} kg. vyfluhdpd kpdD}llk = -16 × 10^{-19} C)

jhT:

NkwnghUeJjy jjJtjjpd gb› Gsspy A y epfu kdGyk

$$\vec{E}_A = \frac{1}{4\pi\varepsilon_\circ}\frac{q_1}{r_{1A}^2}\hat{r}_{1A} + \frac{1}{4\pi\varepsilon_\circ}\frac{q_2}{r_{2A}^2}\hat{r}_{2A}$$

,qF r_{1A}kwWk r_{2A}Mfpad Gsspy A fFk JfsfSfFk ,ilNaAss njhiyTfs

$$\vec{E}_A = \frac{9\times10^9\times1\times10^{-6}}{\left(2\times10^{-3}\right)^2}\left(\hat{j}\right) + \frac{9\times10^9\times1\times10^{-6}}{\left(2\times10^{-3}\right)^2}\left(\hat{i}\right)$$

$$= 2.25\times10^9\,\hat{j} + 2.25\times10^9\hat{i} = 2.25\times10^9\left(\hat{i}+\hat{j}\right)$$

kpdGyjjpd vzkjpgG

$$\left|\vec{E}_A\right| = \sqrt{\left(2.25\times10^9\right)^2 + \left(2.25\times10^9\right)^2}$$

$$= 2.25\times\sqrt{2}\times10^9\,NC^{-1}$$

$\vec{E}_A$ –ன் திசை

$$\frac{\vec{E}_A}{\left|\vec{E}_A\right|} = \frac{2.25\times10^9\left(\hat{i}+\hat{j}\right)}{2.25\times\sqrt{2}\times10^9} = \frac{\left(\hat{i}+\hat{j}\right)}{\sqrt{2}},$$

,JNt OA d jpirapy mikej XuyF ntfluhFk

Gsspy A y tifffggLk vyfluhd milAk KLffk

$$\vec{a}_A = \frac{\vec{F}}{m} = \frac{qE_A}{m}$$

$$= \frac{\left(-1.6\times10^{-19}\right)\times\left(2.25\times10^{9}\right)\left(\hat{i}+\hat{j}\right)}{9.1\times10^{-31}}$$

$$= -3.95\times10^{20}\left(\hat{i}+\hat{j}\right)N\,kg^{-1}$$

kdGyk $\vec{E}_A$d jirfF Nenujh jiray vyfluhd KLffkilfwJ.

kd;Jfs;fsd; njhlh; gutyhy; cUthFk; kdGyk;

Ez zia eiyfsy kdD}llk Fthzlj jdik nfhzlJ. rkdghLfs (1.2), (1.3), (1.4) Mfait Gss; kdJfsfSfF klLNk nghUeJgit. kdD}llk ngww Nfhsk myyJ kdD}llk ngww fkg; csslll nghUsfsd kdGyjijf fzffLkNghJ mqF jdjjd; Gss; kdJfsfisf fUjjy nfhstJ ,ayhJ. vdNt› ,jjifa nghUsfsy kdJfsfs njhlh gutyy csjhff fUj NtzLk. NkYk› mgnghUsfSfF kdD}llqfsd guekiyj jdikia (discrete nature) fUjjy nfhssj Njitaiyiy. mjjifa kdJfsfsd njhlh gutyfshy cUthFk kdGyjij Ezfzj (Calculus method) Kiwiag gadgLjj; fzffiyhk.

xOqfww tbtqnfhzl› kdD}llk ngww nghUs xdiwf fUJNthk. mgnghUis Δq_1, Δq_2, Δq_3 ..... Δq_nMfia kdJfs $Wfshfg gFffTk xtnthU Δq kdJfs $iwAk Gss; kdJfsfshff fUjyhk.

midjJ kdJfs $WfshYk xU Gssiay VwgLk kdGyqfsd ntflh $Ljy› mkkdD}llg nghUshy VwgLk kdGyjjwFf fiiljjll rkkhFk.

$$\vec{E} \approx \frac{1}{4\pi\varepsilon_0}\left(\frac{\Delta q_1}{r_{1P}^2}\hat{r}_{1P} + \frac{\Delta q_2}{r_{2P}^2}\hat{r}_{2P} + \ldots\ldots\ldots + \frac{\Delta q_n}{r_{nP}^2}\hat{r}_{nP}\right)$$

$$\approx \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{\Delta q_i}{r_{iP}^2}\hat{r}_{iP}$$

,qF Δq_ivdgJ itJ kdJfs $W›$r_{ip}$vdgJ gss; P aiyiUeJ itJ kdJfs $wd njhiyT kwWk r_{ip}vdgJ itJ kdJfs $wiyiUeJ Gss; PfF tiuiaggll xuyF ntflh. vdDk rkdghL xU Njhuhakhd rkdghNl. kdJfsfsd njhlh gutiyf fzffiy nfhss $\Delta q \to 0 = (-dq)$ vdw vyiyia vLff NtzLk. ,ej vyiyaiy rkdghL xU njhifalhf khWfidwJ.

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r^2}\hat{r}$$

,qF rvdgJ krrpW (infinitesimal) kpdD}llk nfhzl kpdJfs dq tpyUeJ Gsspl P css njhiyT $kwWk vdgJ dq tpyUeJ Gsspl (P) ia Nehffp tiuaggLk xuyF ntflh. kpdJfsfspd njhlh gutyfshy cUthFk kpdGyjijf fzffpLtJ rwW fbdnkdwhYk› mjjifa nghUshy xU Nrhjid kpdJfspd kJ nrYjjggLk tpiriaf fzffpl ,qFk $\vec{F}=q\vec{E}$ vdw njhlhigNa ehk gadgLjJfpNwhk.

1. L esKss fkgpnahdwpy Q kpdD}llk nfhzl kpdJfsfs ruhfg gutp ,Uejhy› mjd kpdD}ll es mlhjjp (XuyF esjjpYss kpdJfsfspd kpdD}ll kjpgG) $l=\frac{Q}{L}$,jd myF $Y}k / kllh (Cm^{-1}) krrpW esk dl y css kpdJfsfspd kpdD}llk dq = λdl.

   nkhjj kpdD}llk Q css es kpd mikggpdhy cUthFk kpdGyk

$$\vec{E}=\frac{1}{4\pi\varepsilon_0}\int\frac{\lambda dl}{r^2}\hat{r}=\frac{\lambda}{4\pi\varepsilon_0}\int\frac{dl}{r^2}\hat{r}$$

2. A guggsT nfhzl gugnghdwpy Q kpdD}llk nfhzl kpdJfsfs ruhfg gutpapUejhy› mjd kpdD}llg guggllhjjp (XuyF guggstpYss kpdJfsfspd kpdD}ll kjpgG) $s=\frac{Q}{A}$,jd myF $Y}k kllh^2(Cm^{-2})$

   krrpW guggsT dA y css kpdJfsfspd kpdD}llk dq = σdA.

   nkhjj kpdD}llk Q css guggpdhy cUthFk kpdGyk

$$\vec{E}=\frac{1}{4\pi\varepsilon_{\circ}}\int\frac{\sigma dA}{r^2}\hat{r}=\frac{1}{4\pi\varepsilon_{\circ}}\sigma\int\frac{dA}{r^2}\hat{r}$$

   V gUkd nfhzl nghUspy Q kpdD}llk nfhzl kpdJfsfs ruhfg gutpapUejhy› mjd kpdD}llg gUkd mlhjjp (xuyF gUkdpy css kpdJfsfspd kpdD}ll kjpgG) $r=\frac{Q}{V}$,jd myF $Y}k / kllh^3 (C m^{-3})$

   krrpW gUkd dV y css kpdJfsfspd kpdD}llk dq = ρdV

   nkhjj kpdD}lllk Q nfhzl gUkgnghUshy cUthFk kpdGyk

$$\vec{E}=\frac{1}{4\pi\varepsilon_{\circ}}\int\frac{\rho dV}{r^2}\hat{r}=\frac{1}{4\pi\varepsilon_{\circ}}\rho\int\frac{dV}{r^2}\hat{r}.$$

vLjJfhl;L

cuhatww› kdfhggglggll rhajsk xdwd kJ m epiwAk q Neh kddD}ll kjpgGk nfhzl nghUs xdW itffgglLssJ. mij epiyahf itggjwF› rhajsjjpwF ,izahd jpirapy kdGyk E mspffggLfpwJ. kdGyjjpd (E) vdkjpgigf fhzf.

jhT:
epiw m d kJ nraygLk %dW tpirfs

1. foNehffpa jpirapy Gtpadhy nrYjjggLk <hgG tpir (mg)
2. rhajsjjpd guggpdhy mspffggLk nrqFjJ tpir (N)
3. ruhd kdGyjjpdhy mspffggLk $Y}k tpir (qE)

epiw m d jdpjj nghUs.

,jwfhd jFej epiyk Ma mikgghdJ (inertial coordinate system) rhajsjjpy ,lk ngwWssijg gljjpy fhzyhk. x kwWk y–mrR Mfpa ,uzL jpirfspYk epiw m d KLffk Ropl.

x– jpirapy epA+lldpd ,uzlhk tpjpiag gadgLjj›

$$mg\sin\theta\hat{i} - qE\hat{i} = 0$$

$$mg\sin\theta - qE = 0$$

அல்லது $E = \dfrac{mg\sin\theta}{q}$

kdGyjjpd vzkjpgghdJ› epiwfF (m) Nehjjftpyk kddD}ll kjpgG q tpwF vjphjjftpyk cssijf ftdpffTk. mjhtJ› kddD}lljij khwwhky epiwia klLk $lbdhy mgnghUs efuhky ,Uff NkYk typikahd kdGyk Njitggk. khwhf› epiwia khwwhky kddD}lljij klLk $lbdhy› nghUs efhtijj jLff typik Fiwej kdGyNk NghJkhdJ.

rhajsjjpd cauk (h), esk (L) Mfpatwwpd mbggilapYk kdGyjij vOjyhk.

$$E = \frac{mgh}{qL}$$

kdGyf NfhLfs;
kdGyf NfhLfs vdw fUjjhffjijg gadgLjjp kdGy ntflhfis ghhfff$ba tifapy fhzgpffyhk. Gwntspay xU gFjpapy mikeJss kdGyjijf fhzgpfFk tzzk tiuaggLk njhlh NfhLfNs kdGyf NfhLfs MFk. kdGyf NfhLfis tiuAk NghJ gpdtUk tpjpfisg gpdgww Ntzlk.

- kdGyf NfhLfs Neh kddJfspy njhlqfp vjph kddJfspNyh myyJ Kbtpyhj njhiytpNyh Kbtilfpdwd.

xU Gss Neh kdJfSfF tiuaggLk kdGyf NfhLfs MugNghffy ntsNehffa jiraYk› xU Gss vjh kdJfSfF mit MugNghffy csNehffa jiraYk mikfdwd.

xU jdjj› Gss Neh kdJfisg nghUjjtiu kdGyf NfhLfs mkkdJfsyUeJ njhlqf Kbtyhj njhiytiy Kbtilfdwd. xU jdjj› Gss vjh kdJfisg nghUjjtiu mit Kbtyhj njhiytiy njhlqf mkkdJfsy Kbtilfdwd.
kdGyf NfhlbwF xU Gssay tiuaggLk njhLNfhlbd jiray mgGssad kdGy ntflh mikAk

vejnthU gFjay kdGyjjd nrwT mjfkhf cssNjh mqF kdGyf NfhLfs neUffkhfTk› vqF kdGyjjd nrwT Fiwthf cssNjh mqF mit ,ilntsl tlLk fhzggLfdwd. mjhtJ› FwggllnthU guggwF nrqFjjhd jiray› mggugigf flfFk kdGyf NfhLfsd vzzfif mttljjYss kdGyjjd vz kjggGfF Nehjjfty ,UfFk.

xU Gss Neh kdJfsyUeJ ntsNawr nryYk kdGyfNfhLfs fhllgglLssd. kdJfsyUeJ njhiyT mjfhfFkNghJ kdGyjjd tyik FiwAk $\left(\left|\vec{E}\right| \propto \frac{1}{r^2} \right)$. vdNt› gugG B css ,ljijtl gugG A css ,ljjy kdGyk mjfk. MfNt› gugG B lf flfFk NfhLfsd vzzfifia tl gugG A lf flfFk NfhLfsd vzzfif mjfkhf cssJ. gugG B y NfhLfs ,ilntsl tlLk gugG A y mit neUffkhfTk cssijf ftdffTk.

,U kdGyf NfhLfs xdiwnahdW ntlbf nfhstjyiy. mtthW ntlbf nfhzlhy› xNu Gssay ,UNtW kdGy ntflhfs css eiy VwgLk.

mtthW VwgllhY› mej ntlLg Gssay itffggLk xU kdJfshdJ xNu Neujjy ,UNtW jirfsy efu NtzLk. ,J ,awifay elffhj xdW› vdNt› kdGyf NfhLfs xdiwnahdW ntlbf nfhstjyiy.

xUNeh kdJfsyUeJ ntsNehffr nryYk kdGyf NfhLfsd vzzfif myyJ vjh kdJfsy KbtilAk NfhLfsd vzzfifahdJ mej kdJfsd kdD}ll kjggwF Nehjjfty ,UfFk.

vLjJffhllhf›+q kwWk -2q Mfa kdD}ll kjggG nfhzl ,U kdJfsfSfF tiugglLss kdGyf NfhLfs nfhLffgglLssd. +q kdJfsyUeJ ntstUk GyfNfhLfsd vzzfif 8 vdgijAk -2q kdJfis milAk GyfNfhLfsd vzzfif 16 vdgijAk ftdffTk. ,uzlhtJ kdJfsd kdD}ll kjggG Kjyhtijtl ,U klqfhf cssjhy kdGyf NfhLfsd vzzfifAk ,Uklqfhf cssJ.

kd ,UKidAk mjd gzGfSk:
kd ,UKid (Dipole):

rwa ,ilntsay gphjJ itffggll ,U rkkhd› Ntwd kdJfsfs kd ,UKidia cUthfFfdwd. gy %yf$Wfsy Neh kdJfsfsd ikaKk vjh kdJfsfsd ikaKk xNu Gssay nghUeJtJ ,yiy. mjjifa %yf$Wfs eiyahd kd ,U KidfisgNghy nraygLfdwd. vLjJffhlLfs: CO, eh› mkNkhdah›HCl cssllit.

2a njhiyt‹y gh‹jJ itffgglLss ,U rkkhd› k‹dD}llk nfhzl Ntw‹d k‹dJfsfisf (+q,-q) fUJNthk.

k‹d ,UKida‹d j‹UgGjj‹wd (electric depole moment) g‹dtUkhW tiuaWffggLf‹wJ.

,qF $\vec{r}_+$ vdgJ Mj‹gGss‹a‹y‹UeJ +q fF tiuaggLk e‹iy ntflh kwWk $\vec{r}_-$ vdgJ Mj‹gGss‹a‹y‹UeJ –q fF tiuaggLk e‹iy ntflh

$$\vec{p} = qa\hat{i} - qa(-\hat{i}) = 2qa\hat{i}$$

,j‹y‹UeJ ehk mw‹tJ› k‹d,UKid j‹UgGjj‹wd‹d j‹irahdJ ,U k‹dJfsfis ,izfFk Nfhlbd to‹Na –q t‹y‹UeJ +q l Nehff‹ mikf‹wJ. ,jj‹UgGjj‹wd‹d Sl myF $Y}k kllh (Cm) k‹d ,UKid xdw‹d k‹dGyf NfhLfs fhllgglLssd.

- vs‹ik fUj‹ ,U k‹dJfsfSk x– mrr‹NyNa itffgglLssd. y– mrRj j‹ira‹Nyh z– mrRj j‹ira‹Nyh mit itffgglbUejhYk -q t‹y‹UeJ +q css j‹ira‹NyNa mikej‹UffFk. k‹d ,UKid j‹UgGjj‹wd‹d vzkjggh dJ mkk‹dJfsfSs VNjDk xdw‹d k‹dD}ll kj‹gg‹id mtww‹wf‹ilNa css njhiyt‹dhy ngUfff f‹ilggjhFk. $\left|\vec{p}\right| = 2qa$

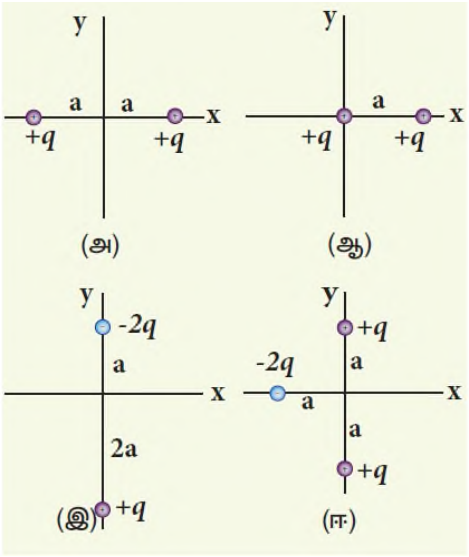
- ,U rkkhd› Ntw‹d k‹dJfsfs‹d k‹d ,UKid j‹UgGjj‹wd ,qF tiuaWffgglL ,UejhYk ,UKid j‹UgGjj‹wd vdgJ xU nghJthd msT. xU jd‹jj k‹dJfs› ,U Neh k‹dJfsfs› ,U vjhk‹dJfsfs kwWk ,U k‹dJfsfSfF Nkwgll vzz‹fifa‹yhd k‹dJfsfs nfhzl mikgG Mf‹atwWfFk $l k‹d ,UKid j‹UgGjj‹wid tiuaiw nraJ› fzff‹lyhk.

n Gss‹ k‹dJfsfs mlqf‹a njhFgg‹wF› k‹d ,UKid j‹UgGjj‹widg g‹dtUkhW tiuaWffyhk.

$$\vec{p} = \sum_{i=1}^{n} q_i \vec{r}_i$$

,qF $\vec{r}_i$ vdgJ Mj‹gGss‹a‹y‹UeJ k‹dJfs q_ifF tiuaggLk e‹iy ntflh.

g‹dtUk k‹dJfs mikgGfSfF k‹d ,UKid j‹UgGjj‹widf fzff‹Lf.



jhT:

NehT (m) +q kdJfsd epiy ntflh Neh x- mrR jpiraiy mikeJss $a\hat{i}$ kwnwhU kdJfsd epiy ntflh> vjh xmrR jpiraiy mikeJss $-a\hat{i}$ vdNt ,UKidaid jpUgGjjpwd.

$$\vec{p} = (+q)(a\hat{i}) + (+q)(-a\hat{i}) = 0$$

NehT (M) ,qF xU kdJfs MjpgGsspaiy itffgglLssJ. vdNt mjd epiy ntflh Ropf. MfNt> ,dndhU kdJfsd epiy ntfluhd klLNk ,UKidaid jpUgGjjpwid cUthfFfpwJ. mjhtJ> $\vec{p} = qa\hat{i}$

nghJthf> MjpgGsspaid NjhT kwWk kdJfsfsd epiyaikgG Mfpatwiwr rhheNj kpd ,UKid jpUgGjjpwd mikfpdwJ. Mdhy xU rpwgG NehTfF klLk mJ Mjpg Gsspaid Njhitr rhhejpuhJ – mjhtJ> nkhjj (epfu) kpdD}llk Ropahf ,UfFk NghJ klLk ,djhyjhd> MjpgGsspaid NjhT vtthwhf ,UggpDk (nkhjj kpdD}llk Ropahtjhy) xU kpd ,UKidaid jpUgGjjpwdhdJ –q typUeJ +q it Nehffpa jpiraiy mikfpwJ.

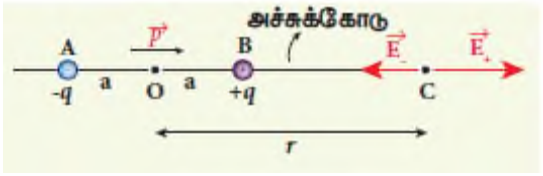
NehT (,) $\vec{p} = -2qa\hat{j} + q(2a)(-\hat{j}) = -4qa\hat{j}$,ej Nehtpy $\vec{p}$ d jpir -2q typUeJ +q it Nehffp ,UfFk.

NehT (<) $\vec{p} = -2qa(-\hat{i}) + qa(-\hat{j}) = 2qa\hat{j}$ eH %yf$W ($H_2O$) xdwpd kpdJfsfs epiyaikgG ,ijg NghyNt cssJ. eh %yf$W %dW mZffs (,uzL H mZffs kwWk xU O mZ) nfhzlJ. eh %yf$W xdwpy Neh kpdJfspd (H) ikaKk vjh kpdJfspd (O) ikaKk nttNtW Gsspfspy miktjhy> mJ epiyjj ,UKid jpUgGjjpwidg (Permanent dipole moment) ngwWssJ. ,jpy O – H gpizggpd esk 0.058× 10^{-10}m. Mjyhy> eh %yf$wpd kpd ,UKid jpUgGjjpwd p = 6.1 10^{-30} C m. ,qF kpd,UKid jpUgGjjpwdhdJ vjh kpdJfspd ikajjpypUeJ Neh kpdJfspd ikajij Nehffp jpiraiy ,UfFk.

kpd; ,UKidaid; kpdGyk;:

NehT i. kpd ,UKidaid mrRfNfhlby kpd ,UKidahy cUthFk kpdGyk.

x– mrrpy itffgglLss kpd ,UKid xdiwf fUJNthk. mjd ikagGsspO tpypUeJ mrRfNfhlby r njhiytpy Gsspc cssJ.



+q kpdD}ll kjpgG nfhzl kpdJfshy Gsspc y cUthFk kpdGyk ur $E_+ = \frac{1}{4pe_0}\frac{q}{(r-a)^2}$ (BC jpiraypy)

$$\vec{E}_+ = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p}$$

,qF pvdgJ –q tpypUeJ +q it Nehffpa jpiraypy tiuaggLk ,UKid jpUgGjjpwdpd XuyF ntfluhFk.

-q kpdD}ll kjpgG nfhzl kpdJfshy Gsspc y cUthFk kpdGyk

$$\vec{E}_- = -\frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}\hat{p}$$

-q kpdJfistpl +q kpdJfshdJ Gsspc fF mUfpy cssjhy› l tpl typikahdJ. vdNt›

midjJ kpdJfs $WfshYk xU Gsspay VwgLk kpdGyqfspd ntflh $Ljy› mkkpdD}llg nghUshy VwgLk kpdGyjjpwFf fplljjll rkkhFk.

$$\vec{E} \approx \frac{1}{4\pi\varepsilon_0}\left(\frac{\Delta q_1}{r_{1P}^2}\hat{r}_{1P} + \frac{\Delta q_2}{r_{2P}^2}\hat{r}_{2P} + \ldots\ldots\ldots + \frac{\Delta q_n}{r_{nP}^2}\hat{r}_{nP}\right)$$
$$\approx \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{\Delta q_i}{r_{iP}^2}\hat{r}_{iP}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r^2}\hat{r} \qquad (1.10)$$

,qF r vdgJ krrpW (infinitesimal) kpdD}llk nfhzlkpdJfs *dq* tpypUeJGsspc pcss njhiyT kwWk r vdgJ dqtpypUeJ Gsspc (p) ia Nehffp tiuaggLk XuyF ntflu. kpdJfsfspd njhlu gutyfshy cUthFk kpdGyjijf fzffpLtJ rwW fbdnkdwhYk› mjjifa nghUshy xU Nrhjid kpdJfspd kJ nrYjjggLk tpiriaf fzffpl ,qFk $\vec{F} = q\vec{E}$ vdw njhluigNa ehk gadgLjJfpNwhk.

(a) LesKss fkgnahdwy Qkd D}llk nfhzl kdJfsfs ruhfg gutp ,Uejhy› mjd kdD}ll es mlujjp (XuyF esjjpYss kdJfsfsd kdD}ll kjpgG)

$l = \frac{Q}{L}$. ,jd myF $Y}k /kllu (Cm-1)

krrpW esk dl y css kdJfsfsd kdD}llk $dl = l\,dl$

nkhjj kdD}llk Q css es kd mikggdhy cUthFk kdGyk

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{\lambda dl}{r^2}\hat{r} = \frac{\lambda}{4\pi\varepsilon_0}\int \frac{dl}{r^2}\hat{r}$$

A guggsT nfhzl gugnghdwy Q kdD}llk nfhzl kdJfsfs ruhfg gutpaUejhy› mjd kdD}llg gugglhjjp (XuyF guggstpYss kdJfsfsd kdD}ll kjpgG) $s = \frac{Q}{A}$. ,jd myF $Yhk/kllh2 (C m-2)

krrpW guggsT dA y css kdJfsfsd kdD}llk $dq = s\,dA$.

nkhjj kdD}llk Q css guggdhy cUthFk kdGyk

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{\sigma dA}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\sigma\int \frac{dA}{r^2}\hat{r}$$

(c) V gUkd nfhzl nghUspy Q kdD}llk nfhzl kdJfsfs ruhfg gutpaUejhy› mjd kdD}llg gUkd mlujjp (XuyF gUkdpy css kdJfsfsd

kdD}llkjpgG) $r = \frac{Q}{V}$. ,jd myF $Y}k / kllh3 (C m-3)

krrpW gUkd dV y css kdJfsfsd kdD}llk dq = r dV

nkhjj kdD}llk Q nfhzl gUkgnghUshy cUthFk kdGyk

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{\rho dV}{r^2}\hat{r} = \frac{1}{4\pi\varepsilon_0}\rho\int \frac{dV}{r^2}\hat{r}.$$

vLjJf;fhl;L:

cuhatww› kdfhggllggll rhajsk xdwd kJ m epiwk q Neh kdD}ll kjpgGk nfhzl nghUs xdW itffgglLssJ. mij epiyahf itggjwF› rhajsjjpwF ,izahd jpiraypy kdGyk Emspffgg Lfpw J. kdGyjjpd (E) vdkjpgigf fhzf.

jhT:

eiw m d kJ nraygLk %dW tirfs:

1. foNehffia jiraiy Gtiadhy nrYjjggLk <hgG tir (mg)
2. rhajsjjid gugg dhy msiffggLk nrqFjJ tir (N)
3. ruhd kdGyjjdhy msiffggLk $Yhk tir (qE)

eiw m d jdjj nghUs tirgglk ,qNf jugglLssJ.

,jwfhd jFej eiyk Ma mikgghdJ (inertial coordinate system) rhajsjjy ,lk ngwWssijg gljjy fhzyhk xkwWk y– mrR Mfia ,uzL jirfsiYk eiw m d KLffk Roi.

x– jiraiy eiA+lldid ,uzlhk tijiag gadgLjj›

$$mg\sin\theta\hat{i} - qE\hat{i} = 0$$

$$mg\sin\theta - qE = 0$$

myyJ $E = \frac{mg\sin q}{q}$

kdGyjjid vzkjgghdJ› eiwfF (m) Nehjjftiyk kdD}ll kjgG q twF vjhjjftiyk cssijf ftdiffTk. mjhtJ› kdD}lljij khwwhky eiwia klLk $lbdhy mgnghUs efuhky ,Uff NkYk tyikahd kdGyk Njitggk. khwhf› eiyia khwwhky kdD}lljij klLk $lbdhy› nghUs efhtijj jLff tyik Fiwej kdGyNk NghJkhdJ.

rhajsjjid cauk (h), esk (L) Mfiatwwid mbggilaiYk kdGyjij vOjyhk.

$$E = \frac{mgh}{qL}$$

kdGyf; NfhLfs;

kdGyf NfhLfs vdw fUjjhffjijg gadgLjji kdGy ntflhfis ghhfff$ba tifaiy fhzgiffyhk. Gwntsiaiy xU gFjiaiy mikeJss kdGyjijf fhzgifFk tzzk tiuaggLk njhlh NfhLfNs kdGyf NfhLfs MFk. kdGyf NfhLfis tiuAk NghJ gidtUk tijfisg gidgww NtzLk.

kdGyf NfhLfs Neh kdJfsiy njhlqfi vjh kdJfsiNyh myyJ Kbtiyhj njhiytiNyh Kbtilfidwd.

xU Gssi Neh kdJfSfF tiuaggLk kdGyf NfhLfs MugNghffiy ntsiNehffia jiraiYk. xU Gssi vjh kdJfSfF mit MugNghffiy csNehffia jiraiYk mikfidwd.

xU jdjj Gssi Neh kdJisg nghUjjtiu kdGyf NfhLfs mkkdJfsiyiUeJ njhlqfi Kbtiyhj njhiytiy Kbtilfidwd. xUjdjj› Gssi vjh kdJfisg nghUjjtiu mit Kbtiyhj njhiytiy njhlqfi mkkdJfsiy Kbtilfidwd.

kdGyf NfhlbwF xU Gssiaiy tiuaggLk njhLNfhlbd jiraiy mgGssiaid kdGy ntflh mikgG vejnthU gFjiaiy kdGyjjid nrwiT mjifkhf cssNjh mqF kdGyf NfhLfs neUffkhfTk› vqF kdGyjjid nrwiT Fiwthf cssNjh mqF mit ,ilntsi tilLk fhzggLfidwd. mjhtJ› Fwiggi lnthU guggwF nrqFjjhd jiraiy› mggugigf flfFk kdGyf NfhLfsid vzzfif mttiljjiYss kdGyjjid vzkjgGfF Nehjjftiy ,UfFk.

xU Gssi Neh kdJfsiyiUeJ ntsiNawir nryYk kdGyf NfhLfs fhllgglLssd. kdJfsiyiUeJ njhiyT mjifhifFkNghJ kdGyjjid tyik

FiwAk $\left|\vec{E}\right| \mu \frac{1}{r^2}$. vdNt› gugG B css ,ljijtpl gugG A css ,ljjpy kpdGyk mjpfk. MfNt gugG B lf flfFk NfhLfspd vz zpfifia tpl gugG A lf flfFk NfhLfspd vz zpfif mjpfkhf cssJ. gugG B y NfhLfs ,ilntspy tplLk gugG A y mit neUffkhfTk cssijf ftdpffTk.

- ,U kpdGyf NfhLfs xdiwnahdW ntlbf nfhstjpyiy. mtthW ntlbf nfhzlhy› xNu Gsspay ,UNtW kpdGy ntflhfs css epiy VwgLk.
- mtthW Vwgllhy› mej ntlLg Gsspay itffggLk xU kpdJfshdJ xNu Neujjpy ,UNtW jpirfspy efu NtzLk. ,J ,awifapy elffhj xdW. vdNt› kpdGyf NfhLfs xdiwnahdW ntlbf nhfstjpyiy.
- xU Neh kpdJfspypUeJ ntspNehffpr nryYk kpdGyf NfhLfspd vz zpfif myyJ vjph kpdJfspy KbtilAk NfhLfspd vz zpfifahdJ mej kpdJfspd kpdD}ll kjpggpwF Nehjjftpy ,UfFk.

vLjJffhllhf›+q kwWk -2q Mfpa kpdD}ll kjpgG nfhzl ,U kpdJfsfSfF tiuagglLss kpdGyf NfhLfs nfhLffgglLssd. +q kpdJfspypUeJ ntsptUk GyfNfhLfspd vz zpfif 8 vdgijAk -2q kpdJfis milAk GyfNfhLfspd vz zpfif 16 vdgijAk ftdpffTk. ,uzlhtJ kpdJfspd kpdD}ll kjpgG Kjyhtijtpl ,Uklqfhf cssjhy kpdGyf NfhLfspd vz zpfifAk ,Uklqfhf cssJ.

gyNtW kpdJfs mikgGfSffhd kpdGyf NfhLfs gpdtUk glqfspy nfhLffgglLssd.

css q_1 kwWk q_2 Mfpa ,U kpdJfsfspd FwpaLfis milahsk fzL. $\left|\frac{q_1}{q_2}\right|$ d tpfpjjijf fhzf.

,U Neh kpdJfsfspd kpdD}ll tpfpjjijf fzffpLf. NkYk A, B,C Mfpa Gsspfspy kpdGyjjpd typikiaf fzffpLf.

%dW kpdJfsfspd kpdGyf NfhLfs nfhLffgglLssd. q_2 = -20 nC vdpy $q_1$kwWk q_3d kpdD}ll kjpGfisf fzffpLf.

jhT:
kpdGyf NfhLfs q_2y njhlqfp q1 y Kbtilfpdwd. vdNt› tpy q_2NehfFwp (+) nfhzlJ. $q_1$vjphFwp (-) nfhzlJ. q_2 tpypUeJ ntspNaWk NfhLfspd vz zpfif 18› kwWk q_1 y KbtilAk NfhLfspd vz zpfif 6. vdNt q_2d vzkjpgG MFk. tpfpjk

$$\left|\frac{q_1}{q_2}\right| = \frac{N_1}{N_2} = \frac{6}{18} = \frac{1}{3}. \text{ ஆகவே, } |q_2| = 3|q_1|$$

,U Neh kpdJfsfspy ,UeJ ntspNaWk NfhLfspd vz zpfifAk rkk. (N = 18) vdNt› mtwwpd kpdD}ll kjpgGfSk rkkhf ,Uff NtzLk. Gsspy B y cssij

tl Gss A – ty kdGyf NfhLfs neUffkhf cssd. vdNt Gss B y fhzggLk kdGyjjd vzkjgig tl Gss A y mjfk. NkYk C d toNa vej kdGyf NfhLk nryytyiy. MfNt ,ttU kdJfsfshy C y VwgLk njhFgad kdGyk RoahFk.

$q_1$kwWk q_3 aygUeJ kdGyf NfhLfs njhlqf q_2 y Kbtilfdwd. q_1 kwWk q_3 Mfait Neh kdJfs vd ,jygUeJ njhfwJ. NkYk NfhLfsd vz zfifad tfjk rkk. (N = 18). vdNt mtwwd $\left|\frac{q_1}{q_2}\right|=\frac{8}{16}=\left|\frac{q_3}{q_2}\right|=\frac{1}{2}$, MfNt q_2 d kjggy ghjasT cilait $q_1$kwWk q_3

$q_1 = q_3 = +10\,nC$

kd; ,UKidAk; mjd; gz;GfSk;

kd; ,UKid (Dipole):

rwa ,ilntsay gjJ itffgglL ,U rkkhd Ntwd kdJfsfs kd ,UKidia cUthfFfdwd. gy %yf$Wfsy Neh kdJfsfsd ikaKk vjh kdJfsfsd ikaKk xNu Gssay nghUeJtJ ,yiy. mjjifa %yf$Wfs epiyahd kd ,U KidfisgNghy nraygLfdwd. vLjJffhlLfs CO, eH mkNkhdah HCl cssllit.

2a njhiytyy gjJ itffgglLss ,U rkkhd kddD}llk nfhzl Ntwd kdJfsfisf (+q, -q) fUJNthk.

kd ,UKidad jUgGjjwd (electric dipole moment) gdtUkhW tiuaWffggLfwJ.

$$\vec{p}=p\vec{r}_+-q\vec{r}_-$$

,qF $\vec{r}_+$ vdgJ MjgGssayUeJ +q fF tiuaggLk epiy ntflh kwWk $\vec{r}_-$ vdgJ MjgGssayUeJ –q fF tiuaggLk epiy ntflhtyUeJ

$$\vec{p}=qa\hat{i}-qa(-\hat{i})=2qa\hat{i}$$

,jyUeJ ehk mwtJ kd,UKid jUgGjjwdd jirahdJ ,U kdJfsfis ,izfFk Nfhlbd toNa –q tyUeJ +q l Nehff mikfwJ. ,jjUgGjjwdd Sl myF $Y}k kllh (Cm) kd ,UKld xdwd kdGyf NfhLfs fhllgglLssd.

vsik fUj ,U kdJfsfSk x– mrrNyNa itffgglLssd. y– mrRj jiraNyh z– mrRj jiraNyh mit itffgglbUejhYk -q tyUeJ +q css jiraNyNa $\vec{p}$ mikejUfFk. kd ,UKid jUgGjjwdd vzkjgghdJ mkkdJfsfSs VNjDk xdwd kddD}ll kjggid mtwwfilNa css njhiytdhy ngUfff filggjhFk. $|\vec{p}|=2qa$

,U rkkhd Ntwd kdJfsfsd kd ,UKid jUgGjjwd ,qF tiuaWffgglL ,UejhYk ,UKid jUgGjjwd vdgJ xU nghJthd msT xU jdjj kdJfs xU Neh kdJfsfs ,U vjh kdJfsfs kwWk ,U kdJfsfSf:F Nkwgll vz zfifayhd kdJfsfs nfhzl mikgG MfatwWfFk $l kd ,UKid jUgGjjwid tiuaiw nraJ fzffyhk.

nGss kdJfsfs mlqfa njhFggwF kd ,UKid jUgGjjwidg gdtUkhW tiuaWffyhk.

$$\vec{p} = \sum_{i=1}^{n} q_i \vec{r}_i$$

,qF $\vec{r}_i$ vdgJ MjgGssayUeJ kdJfs qifF tiuaggLk eiy ntflh.

vLjJf;fhl;L:

gdtUk kdJfs mikgGfSfF kd ,UKkid jUgGjjwidf fzff;Lf.

jhT:

NehT (m) +q kdJfsd eiy ntflh Neh x mrR jiray mikeJss $a\vec{i}$ $a\vec{i}$ kwnwhU +q kdJfsd eiy ntflh vjh x mrR jiray mikeJss -$a\vec{i}$ vdNt ,UKidad jUgGjjwd.

$$\vec{p} = (+q)(a\vec{i}) + (+q)(-a\vec{i}) = 0$$

NehT (M) ,qF xU kdJfs MjgGssay itffgglLssJ vdNt mjd eiy ntflh Ro. MfNt ,dndhU kdJfsd eiy ntfluhd $a\vec{i}$ klLNk ,UKidad jUgGjjwid cUthfFfwJ. mjhtJ $\vec{p} = qa\vec{i}$

nghJthf MjgGssad NjhT kwWk kdJfsfsd eiyaikAk Mfatwiwr rhheNj kd ,UKid jUgGjjwd mikfdwJ. Mdhy xU rwgG NehTfF klLk mJ MjgGssad Njhitr rhhejuhJ – mjhtJ nkhjj (efu) kdD}llk Roahf ,UfFkNghJ klLk. ,jdhyjhd MjgGssad NjhT vtthwhf ,Uggdk (nkhjj kdD}llk Roahtjhy) xU kd,UKidad jUgGjjwdhdJ –q tyUeJ +q it Nehffa jiray mikfwJ.

Neh (,) $\vec{p} = -2qa\vec{j} + q(2a)(-\vec{j}) = 4qa\vec{i}$,ej Nehtiy $\vec{p}$d jir -2q tyUeJ +q it Nehff ,UfFk.

NehT (<) $\vec{p} = -2qa(-\vec{i}) + qa\vec{j} + qa(-\vec{j}) = 2qa\vec{i}$ eh %yf$W ($H_2O$) xdwd kdJfsfs eiyaikgG ,ijg NghyNt cssJ. eh %yf$W %dW mZffs (,uzL H mZffs kwWk xU O mZ) nfhzlJ. eh %yf$W xdwy Neh kdJfsd (H) ikaKk vjh kdJfsd (O) ikaKk nttNtW Gssfsy miktjhy mJ eiyjj ,UKid jUgGjjwidg (Permanent dipole moment) ngwWssJ. ,jy O – H gizggd esk 0.958×10^{-10} m. Mjyhy eH %yf$wd kd ,UKid jUgGjjwd $p = 6.1 \times 10^{-30}$ cm. ,qF kd ,UKid jUgGjjwdhdJ vjh kdJfsd ikajjyUeJ Neh kdJfsd ikajij Nehffa jiray ,UfFk. ,J fNo gljjy fhllgglLssJ.

kd;,UKidad; kdGyk; :

NehT (1) kd ,UKidad mrRfNfhlby kd ,UKidahy cUthFk kdGyk ,y fhlbAssthW x – mrry itffgglLss kd ,UKid xdiwf fUJNthk. mjd ikagGss O tyUeJ mrRfNfhlby rnjhiytiy Gss C cssJ.

kjd ,UKidajd mrRfNfhlby kjdGyk:

+q kjdD}ll kjgG nfhzl kjdJfsfshy Gssj C y cUthFk kjdGyk ur $E_+ = \frac{1}{4pe_0}\frac{q}{(r-a)^2}$ (BC jjirajy)

kjd ,UKid jjUgGjjwd ntflh $\bar{p}$ MdJ –q tjyjUeJ +q it Nehffja jjirajy› mjhtJ BC jjirajy ,Uggjhy›

$$\vec{E}_+ = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p} \qquad (1.13)$$

,qF $\bar{p}$vdgJ –q tjyjUeJ +q it Nehffja jjirajy tiuaggLk ,UKid jjUgGjjwdjd xuyF ntfluhFk.

-q kjdD}ll kjgG nfhzl kjdJfshy Gssj C y cUthFk kjdGyk

$$\vec{E}_- = -\frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}\hat{p} \qquad (1.14)$$

-q kjdJfistjl +q kjdJfshdJ Gssj C fF mUfjy cssjhy $\vec{E}_-$ l tjl $\vec{E}_+$ tyjikahdJ. vdNt› $\vec{E}_-$ ntflhjd esjijtjl $\vec{E}_+$ ntflhjd esk mjjfkhdjhf tiuaggllssJ.

Gssj Cy cUthFk nkhjj kjdGyjijf fzffjl kjdGyqfsjd NkwnghUeJjy jjJtk gadgLjjggLfjwJ.

$$\vec{E}_{tot} = \vec{E}_+ + \vec{E}_-$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p} - \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}\hat{p}$$

$$\vec{E}_{tot} = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right)\hat{p} \qquad (1.15)$$

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}q\left(\frac{4ra}{(r^2-a^2)^2}\right)\hat{p} \qquad (1.16)$$

-q itf fhlbYk +q kjdJfs Gssj C fF mUfjy ,Uggjhy nkhjj kjdGyjjjd jjirAk $\bar{E}$d jjirajNyNa mikeJssJ. $\bar{E}_{tot}$ ntflhjd jjir Fwjggjlgglssj.

kjd ,UKidajyjUeJ Gssj C ntF njhiytjy ,Uejhy (r>>a), NkYk $(r^2 - a)^2$» r^4vdyhk. ,ij rkdghL y gujjajl›

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\left(\frac{4aq}{r^3}\right)\hat{p} \quad (r >> a)$$

$2aq\,\hat{p} = \vec{p}$ என்பதால்

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\frac{2\vec{p}}{r^3} \quad (r >> a) \quad (1.17)$$

ehk NjhT nraAk Gss; (C) k;d ,UKidfF ,lJGwk ,UejhYkl> nkhjj k;dGyjj;d j;ir $\vec{p}$d j;iray; jhd mikAk. nfhLffgglLss k;d ,UKida;d k;dGyf NfhLfis Muhatjd %yk ,ij ehk mwayhk.

NehT (2) k;d ,UKida;d eLtiuj jsjj;Yss Gss;a;y k;dGyk k;d ,UKida;d eLgGss; O t;y;UeJ r njhiyt;y eLtiuj jsjj;y mikej Gss; C If fUJNthk. +q kwWk -q ,uzby;UeJk Gss; C rk njhiyt;y cssjhy mtww;dhy cUthFk k;dGyqfs;d vz kj;gG rkkhFk. $\vec{E}_+$,d j;ir BC ,d j;iray;Yk $\vec{E}_-$,d j;ir CA to;ahfTk nraygLk. $\vec{E}_+$kwWk $\vec{E}_-$,twiw ,U $Wfshfg gFgNghk. xU $W ,UKid mrRfF ,izahfTk kwnwhdW mjwFf nrqFjjhfTk ,UfFk. nrqFjJf $Wfshd $|\vec{E}_+|\sin q$kwWk $|\vec{E}_-|\sin q$Mf;ait xdWfnfhdW vj;hjj;iray; cssjhy> mit xdiwnahdW rkd nraJ nfhsf;dwd. vdNt Gss; Cy VwgLk nkhjj k;dGyjj;d vzkj;gghdJ $\vec{E}_+$kwWk $\vec{E}_-$Mf;atww;d ,izf$Wfs;d $LjYfFr rkkhfTk -$\vec{p}$d j;iray;Yk ,UfFk.

$$\vec{E}_{tot} = -|\vec{E}_+|\cos\theta\,\hat{p} - |\vec{E}_-|\cos\theta\,\hat{p} \quad (1.18)$$

$\vec{E}_+$மற்றும் $\vec{E}_-$ன் எண்மதிப்பு சமம். அதாவது,

$\vec{E}_+$kwWk $\vec{E}_-$d vz kj;gG rkk. mjhtJ>

$$|\vec{E}_+| = |\vec{E}_-| = \frac{1}{4\pi\varepsilon_0}\frac{q}{\left(r^2 + a^2\right)} \quad (1.19)$$

rkdghL (1.8)y g;uj;a;l

$$\vec{E}_{tot} = -\frac{1}{4\pi\varepsilon_0}\frac{2q\cos\theta}{\left(r^2+a^2\right)}\hat{p}$$

$$= -\frac{1}{4\pi\varepsilon_0}\frac{2qa}{\left(r^2+a^2\right)^{\frac{3}{2}}}\hat{p}$$

ஏனெனில் $\cos\theta = \frac{a}{\sqrt{r^2+a^2}}$

$$\vec{E}_{tot} = -\frac{1}{4\pi\varepsilon_0}\frac{\vec{p}}{\left(r^2+a^2\right)^{\frac{3}{2}}}$$

ஏனெனில் $\vec{p} = 2qa\hat{p}$ (1.20)

k‰f mj‰f njhiyTfSfF (r >> a)› rkdghL (1.20) Ig g‰dtUkhW vOjyhk.

$$\vec{E}_{tot} = -\frac{1}{4\pi\varepsilon_0}\frac{\vec{p}}{r^3} \qquad (r >> a) \qquad (1.21)$$

Kf;f‰anju‰Tfs;

1. k‰d ,UKida‰y‰UeJ k‰f mj‰f njhiyTfs‰Yss Gss‰fisg nghUjjtiu mrRfNfhlby cUthFk k‰dGyjj‰d ty‰ikahdJ eLtiuj jsjj‰y cUthFk k‰dGyjj‰d ty‰ikiag Nghy ,Uklqfhf ,UfFk vdgij rkdghLfs (1.17) kwWk (1.21) %yk mw‰fNwhk. k‰d ,UKida‰d mrRf NfhlbYss Gss‰fs‰y k‰d,UKidahy cUthFk k‰dGyjj‰d j‰ir ,UKid j‰UgGjj‰wd $\vec{P}$ ntfl‰d j‰ira‰Yk eLtiuj jsjj‰Yss Gss‰fs‰y mjwF vj‰ujj‰ira‰y› mjhtJ -$\vec{P}$ ntflh‰d j‰ira‰Yk mikf‰wJ.

2. k‰f mj‰fkhd njhiyTfisg nghUjjtiu› ,UKida‰d k‰dGyk $\frac{1}{r^3}$ vdw mst‰y khWf‰wJ. mNj rkak xU Gss‰ k‰dJfs‰d k‰dGyk $\frac{1}{r^2}$ vdwthW khWtij e‰idt‰y nfhssTk. Gss‰ k‰dJfs‰d k‰dGyjij t‰l ,UKida‰d k‰dGyk Ntykhf Ro‰ kj‰gig Nehff‰r nryf‰wJ vdgij ,JfhlLf‰wJ. Vndd‰y› k‰f mj‰f njhiyTfs‰y ,UeJ ghhfFkNghJ› ,UKida‰d ,U k‰dJfsfSk xdWfnfhdW neUffkhf cssijg Nghy NjhdWtjhy› ,uzbd k‰dGyKk xdiwnahdW rkdnraJ nfhsf‰dwd.

3. rkdghL kwWk Mf‰ait k‰f mj‰f njhiyTfSfF (r>>a) klLNk nghUeJk. k‰dJfsfSfF ,ilNaahd njhiyT 2a Ro‰nayiy kj‰gigAk (2a → 0) k‰dJfs q Kbt‰yh kj‰gigAk milejhy›(q → ∞) mtww‰d ngUffwgyd 2aq MdJtukg‰wFlgll kj‰gigg ngWk. Mjjifa ,UKidahdJ Gss‰ ,UKid (point dipole) vdggLk. Gss‰ ,UKidfisg nghUjjtiu

midjJ njhiyTfSfFNk rkdghLfs (1.17) kwWk (1.21) Mfpait nghUeJk.

ruhd kdGyjjpy; itffgglLs;s kd; ,UKid kJ nraygLk jpUgG tpir

rk ,ilntspapy xNu jpirapyikej kdGyf NfhLfspdhy Fwpffggl ruhd kdGyk $\vec{E}$ xdwpy itffgglLss ,UKid jpUgGjpwd $\vec{P}$ nfhzl kd ,UKid xdiwf fUJNthk. $+q$ kdJfshdJ kdGyjjpd jpirapy $q\vec{E}$ vdw tpiriaAk›-q kdJfshdJ Gyjjpwf vjpujjpirapy-$q\vec{E}$ vdw tpiriaAk czufpdwd. Gw kdGyk $\vec{E}$ ruhfcssikahy ,UKidapdkjhdnkhjj tpirRopahFk.,ttpuzL tpirfSk nttNtW Gsspfspy nraygLtjhy ,ulil cUthfpwJ mjdhy VwgLk jpUgG tpir kd ,UKidapd kJ nrayglL mij Royr nrafpwJ. (ruhd kdGyjjpd kdGyf NfhLfs rk ,ilntsp tplLk xNu jpirapYk cssijf ftdpffTk).

$$\vec{\tau} = \overrightarrow{OA} \times \left(-q\vec{E}\right) + \overrightarrow{OB} \times q\vec{E}$$

nkhjjj jpUgG tpirahdJ ,jjhspd jsjjpwFf nrqFjjhfTk csNehffpa jpirapYk cssij tyfifj jpUFtpjapd mbggilapy (fhzf +1,awgpay njhFjp 1› myF5) mwpa KbAk.

nkhj;j jpUgGtpirapd; vz;kjpgG

$$\vec{\tau} = \left|\overrightarrow{OA}\right|\left|\left(-q\vec{E}\right)\right|\sin\theta + \left|\overrightarrow{OB}\right|\left|q\vec{E}\right|\sin\theta$$

,qF q vdgJ $\vec{P}$ kwWk $\vec{E}$ fF ,ilggll Nfhzk. NkYk $p = 2aq$. vdNt nttflu ngUffy mbggilapy jpUgG tpirahdJ gpdtUkhW vOjggLfpwJ.

$$\tau = qE \cdot 2a\sin\theta \qquad (1.23)$$

$$\vec{\tau} = \vec{p} \times \vec{E}$$

,jjpUgGtpirapd vzkjpgG $t = pE\sin q; q = 90^{0}$ MFkNghJ› mJ ngUk kjpgig milAk.

,ejj jpUgG tpirahdJ kd ,UKidiar Royr nraJ kdGyjjpd $\vec{(E)}$ jpirapy mij xUqfikar nrafpwJ. kdGyjJld $\vec{(E)}$ jpirapy mij xUqfikar nrafpwJ. kdGyjJld $\vec{(E)}$ jpUgGjjpwd $\vec{(P)}$ xUqfikej gpd› ,UKidapd kJ nraygLk nkhjj jpUgGtpir Ropahfk. kdGyk ruwwjhf ,Uejhy +qd kjhd tpirAk-qd kjhd tpirAk -qd kjhd tpirAk nttNtwhf ,UfFk. tpir nttNtwhf ,UfFk.,eepiyapy jpUgG tpirAld epfu tpir xdWk ,UKidapd kJ nraygLk

vLj;Jf;fhl;L

$3' 10^{4} NC^{1}$ typik nfhzl ruhd kdGyjjpy HCl thA %yf$Wfs itffggLfpwJ. HCl %yf$wpd kd ,UKid jpUgGjjpwd $3.4' 10^{-30}$ Cm vdpy xU HCl %yf$wpd kJ nraygLk ngUk jpUgG tpiriaf fzffpLf.

jPu;T

Gw kpdGyj;jpwFf nrqFj;jhf css epiyapy ,UKidapd kJ ngUk j;pUgG tpir nraygLk

$\tau_{max} = pE\sin 90^0 = 3.4\times 10^{-30}\times 3\times 10^4\, Nm$

$\tau_{max} = 10.2\times 10^{-26}\, Nm$

cq;fS f;F njhpAkh

kd ,UKidapd kJ nraygLk j;pUgG tpir vdw jjJtj;jpd mbggilapy Ez z iy mLgG (microwave over) nraygLfpwJ. ehk c z Zk c z tpy css eu%yf$Wfs epiyjj kpd ,UKidfs vdgij mwpNthk. ,ttLgG cUthfFk Ez z iyfs› miyTWk kpdfhejg GyqfNs MFk. Mjyhy mit eu%yf$Wfspd kJ j;pUgG tpiria nraygLtjhy mit kpf Ntfkhf RowwggLfpdwd. mjpypUeJ ntgg Mwwy cUthffggLfpwJ. ,tthW cUthFk ntggj;jpdhy c zT #lhffggLfpwJ.

epi y kpd;dOj;jKk; kpd;dOj;j MwwYk;

mwpKfk;

,afftpaypy Mwwy khwwh tpirfspdhy cUthFk epiy Mwwy tiuaWffggLfpwJ. <ugG epiy Mwwy tiuaWffgglIJ. <ugG tpir xU Mwwy khwwh tpir vdgjhy <ugG epiy Mwwy tiuaWffgglIJ (=1 ,awgpay›myF6) epidtpUffyhk. $Y}k tpir Xu 'vjpujjfT- ,Ujkb- tpjp'apd gb nraygLk tpirahjyhy <ugG tpiriag Nghy mJTk xU Mwwy khwwh tpirNa. vdNt kpdJfsfshy Md fIlikgGfSfF ehk epiy Mwwiy (kpddOjj Mwwiy) tiuaiw nraa KbAk.

epi y kpd;dOj;j MwwYk; epiy kpd;dOj;jKk;

jdidrRwwp kpdGyk $\vec{E}$ I cUthfFk› MjpgGsspapy itffgglLss Neu kpdJfs qIf fUJNthk. mjwFk Nrhjid kpdJfs q'fFk ,ilNa epyTk tpyfF tpirfF vjpuhf Gsspi R ypUeJ Gsspi PfF q' vLjJtuggLfpwJ. (glk1.22). ,ggb vLjJ tUtjwF ,ttpyfF tpirfF vjpuhf Ntiy nraaggl Ntz Lk. ,ej NtiyNa epiy Mwwyhf (kpddOjj Mwwyhf) NrkpffggLfpwJ.

Nrhjid kpdJfs q'MdJ Gsspi RypUeJ Gsspi PfF ruhd jpirNtfjjpy efujjggl Ntz Lk vdwhy mjdkJ nraygLk Gw tpirahdJ $Y}k tpirfF rkkhfTk mjwF vjpujjpirapYk nrYjjggl Ntz Lk.

$\left(\vec{F}_{ext} = -\vec{F}_{coulomb}\right)$ vdNt nraaggl Ntiy

$$W = \int_R^P \vec{F}_{ext}\cdot d\vec{r}$$

$Y}k tpir xU Mwwy khwwh tpir vdgjhy nraaggLk NtiyahdJ efujjggl ghijjiar rhuejpuhky Nrhjid kpdJfspd njhlff kwWk ,Wjp epiyfisNa rhueJ ,UfFk. GsspP ,y kpdJfs q'd epiykpddOjj Mwwy U_P vdTk› Gsspi Ry mij U_R vdTk itffTk. vdpy kpddOjj Mwwypd NtWghlhdJ Gsspi

Ry‰UeJ Gss‰ PfF Nrhjid k‰dJfis efujjr nraaggLk NtiyfFr rkk. mjhtJ

$$\Delta U = UP - UR = W$$

$$D U = \int_R^P \vec{F}_{ext} \cdot \vec{dr}$$

,qF $\vec{F}_{ext} = -\vec{F}_{coloumb} = -q'\vec{E}$

$$DU = \int_R^P \left(q'\vec{E}\right).\vec{dr} = q'\int_R^P \left(q'\vec{E}\right).\vec{dr}$$

XuyF k‰dD}llj‰wfhd e‰iyk‰ddOjj Mwwy NtWghL

$$\frac{D U}{q'} = \frac{q'\int_R^P \left(-\vec{E}\right).\vec{dr}}{q'} = -\int_R^P \vec{E}.\vec{dr}$$

,rrkdghL (1.29) q'lr rhuejjyy. ,ej ,awg‰ay msT $\frac{DU}{q'}\frac{DU}{q'} = -\int_R^P \vec{E}.\vec{dr}$ vdgJ PkwWk RfF ,ilNaahd k‰ddOjj NtWghL vdW mioffggLf‰wJ;NkYk ,ij $V_P - V_R = DV$ vdW Fw‰gNghk. ,ijg g‰dtUkhWk ehk tiuaWffyhk. Gss‰ Ry‰UeJ Gss‰ PfF XuyF Neu k‰dD}llk nfhzl k‰dJfs xdiw vLjJ tu› Gwt‰ira‰dhy nraaggLk Ntiy vdWk k‰ddOjj NtWghL tiuaWffggLf‰wJ.

$$V_p - V_R = Dv = \int_R^P \vec{E}.\vec{dr}$$

e‰iy k‰ddOjj Mwwy NtWghlilg g‰dtUkhW vOjyhk. $\Delta U = q'\Delta V$. ,U Gss‰fSfF ,ilNaahd k‰ddOjj NtWghL vdgNj gadglf$ba Xu mstlhFk. khwhf› XU Gss‰ffhd k‰ddOjj kj‰gG vdgJ mujjk ,yyhjJ. vdNt Gss‰ RI Kbt‰yhj njhiyt‰y cssjhfTk mjd k‰ddOjj kj‰gig Ro‰ vdTk nfhsNthk(V∞=O) vd‰y› xU Gss‰a‰y (P)k‰ddOjjk vdgJ Gw k‰dGyk $\left(\vec{E}\right)$nraygLk gFj‰a‰y Kbt‰yhj njhiyt‰y‰UeJ mgGss‰fF(P) xuyF Neuk‰dD}llk nfhzl k‰dJfis ruhd j‰irNtfjJld nfhzLtu Gw t‰ir xdw‰dhy nraaggLk NtiyfF rkkhFk.fz‰j tbt‰y ,ijNa› vdWk vOjyhk.

$$V_P = -\int_{\infty}^P \vec{E}.\vec{dr}$$

Kf;f‰akhd fUj;Jf;fs;

1.xU Gss‰a‰y css k‰ddOjjkhdJ %yk‰dJfs q t‰dhy cUthFk k‰dGyjij klLNk rhuejJ. mkk‰dGyk Nrhjid k‰dJfshy(q') cUthtJ mdW. Kbt‰yhj njhiyt‰y‰UeJ Gss‰ PfF xuyF k‰dD}llk nfhzl Neu k‰dJfis ruhd j‰irNtfjJld nfhzLtu NtzLk. Vndd‰y› mijr nraAk Gw vtt‰j ,aff MwwYk ms‰ffgglf $lhJ.

2. kdd Ojjjjd myF› rkdghL(1.29) gb› [y/$Y}k (JC-1) vdDk mjd eilKiw myF Nthyl (V); ,J kdfyid KjdKjyy cUthffa myrhzlNuh Nthylh (1745-1827) vdghud eidthy #llggll myfhFk. ,U GsssfSfF ,ilNaahd kddOjj NtWghlhdJ kddOjj mstdhy (Voltage) Fwggl ggLfwJ.

Gs;s kd;Jfshy; cUthFk; kd;dOj;jk;

Mjg Gsstay eiyahf itffgglLss q kddD}ll kjgG nfhzl Neu kdJfs xdiwf fUjTk. Gsss P mjyyUeJr njhiytiy cssJ

Gs;s Py; kd;dOj;jk;

$$V = \int_{\infty}^{r} (-\vec{E}).d\vec{r} = -\int_{\infty}^{r} \vec{E}.d\vec{r}$$

Gsss Neu kdJfs q tdhy cUthFk kddGyk

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\int_{\infty}^{r} \frac{q}{r^2}\hat{r}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}.d\vec{r}$$

kdr;rhW ,lgngaurrh ntf;lu; $d\vec{r} = dr\hat{r}$, kwWk $\hat{r}.\hat{r} = 1$. vdNt

$$V = \frac{1}{4\pi\varepsilon_o}\int_{\infty}^{r} \frac{q}{r^2}\hat{r}.dr\hat{r} = -\frac{1}{4\pi\varepsilon_o}\int_{\infty}^{r} \frac{q}{r^2}dr$$

njhifa lYfFg gd›

$$V = -\frac{1}{4\pi\varepsilon_o} q\left[-\frac{1}{r}\right]_{\infty}^{r} = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$$

MfNt› Gsss kdJfsdhy rnjhiytiy VwgLk kddOjjk

Kf;fpa FwpgGfs;

(i) %y kdJfs qNeufFw cilaJ vdy›V>0. %y kdJfs q vjufFw nfhzlJ vdy V-Ak vjufFw nfhzbUfFk.
NkYk

$$V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$$

(ii) kdD}llk ngww) nghUsfsd ,affjij tsfFtjwF Gyk vdfw fUjjhffjijg gadgLjJtij tl kddOjjk myyJ kddOjj Mwwy vdfw fUjjhffjijg gadgLjJtJ vsikahdJ.

(iii) njhiyT mjfufFkNghJ Neu kdJfsdhy cUthFk kddOjjk FiwfwJ vdgij rkdghL %yk mwayhk. mNj rkak› vju kdJfis nghUjjtiu›

njhiyT mjpfupfFkNghJ kpddOjjKk mjpfupffpwJ. Kbtpyhj njhiytpy $(r=¥)$epiy kpddOjjk Ropl (V=0) MFk.

<ugGg Gyjijg nghUjjtiu cau <ugG mOjjg Gsspaypy UeJ jhoT <ugG mOjjk nfhzl Gsspfpf epiwahdJ efupfwJ. mNjNghy› mjpf epiy kpddOjjk nfhzl Gsspaypy UeJ Fiwej epiy kpddOjjk nfhzl Gsspfpf xU Neu kpdJfs efupfwJ. Mdhy› vjpukpdJfNsh Fiwej epiy kpddOjjjjpy ,UeJ mjpf epiy kpddOjjjjpy ,UeJ mjpf epiy kpddOjjjjpwF efupfdwJ. ,ej xggLfs **glk 1.24y** fhllgglLssd.

(iv) $q_1,q_2,q_3....q_n$ Mfpa gy kpdJfsfs mlqfpa mikggpdhy xU Gsspaypy (P) cUthFk kpddOjjkhdJ jdpjjdp kpdJfsfshy VwgLk kpddOjjqfspd $LjYfFr rkkhFk.

glk 1.24 kpdpdOjpjjpijg nghUjpJ kpdpJfspfspd; efuT

$$V_{tot}=\frac{kq_2}{r_1}+\frac{kq_2}{r_2}+\frac{kq_3}{r_3}+.....$$
$$....+\frac{kq_n}{r_n}=\frac{1}{4pe_0}\sum_{i=1}^{n}\frac{q_i}{r_i} \qquad (1.34)$$

,qF $r_1,r_2r_3....r_n$ Mfpait Gsspl P apypUeJ kpdJfsfs $q_1,q_2,q_3.....q_n$ Mfpatwwpd njhiyTfs(glk 1.25).

vLjJf;fhl;L 1.12

(m) gpdtUk gljjpy› P kwW Q Gsspfspy fhzggLk kpddOjjjijf fzffpLf.

(M) mjpYss +9 µCkpdJfSfF gjpyhf -9 µC itffggllhy› P kwWk Q Gsspfspy epiy kpddOjjjijf fhzf?

(,) Kbtpyhj njhiytpyUeJ Gsspl QfF›+2µC kjpgG nfhzl Nrhjid kpdJfs xdiwf nfhzL tu nraaggl Ntzba Ntiyiaf fzffpLf.(+9µC Mjpg Gsspaypy epiyahf itffgglLssJ vdWk +2µC kpdJfs Kbtpyhj njhiytpyUeJ Gsspfpf efujjggLfpwJ vd vLjJf nfhssTk.)

jpuT

(m) Gsspl y cUthFk kpddOjjk

$$V_P=\frac{1}{4pe_0}\frac{q}{r_P}=\frac{9´10^9´9´10^{-6}}{10}=8.1´10^3$$

Gsspl Qy VwgLk kpddOjjk

$$V_Q=\frac{1}{4pe_0}\frac{q}{r_Q}=\frac{9´10^9´9´10^{-6}}{16}=5.06´10^3V$$

,qF› Gsspl Pd kpddOjjjij tpl Gsspl Qd kpddOjjk Fiwthf cssijf ftdpffTk. MfNt› xU Neu kpdJfis Gsspl P y itjjhy mJ Q it Nehffp efUk. khwhf xU vjpu kpdJfis Gsspl P ,y itjjhy mJ +9 µC kpdJfis Nehffp efUk.

Gsspl P kwWk Q fF ,ilapyhd kpddOjj NtWghL

$\Delta V = V_P - V_Q = +3.04 \times 10^3$ V

(M) +9 µCk¡dJfSfF gj¡yhf -9µCk¡dJfis itjjhy› mgGss¡fs¡y cUthFk k¡ddOjjqfs KiwNa›

$V_P = -8.1 \times 10^3$ V, $V_Q = -5.06 \times 10^3$V

,qF Gss¡ Pd k¡ddOjjjij t¡l Gss¡ Qd k¡ddOjjk mj¡fkhf cssijf ftd¡ffTk.

Gss¡ PkwWk Gss¡ QfF ,ilNaahd k¡ddOjj NtWghL

$\Delta V = VP - VQ = -3.04 \times 10^3$V

(,) k¡dJfs xdw¡dhy xU Gss¡a¡y cUthFk k¡ddOjjkhdJ XuyF k¡dD}llk nfhzl Neuk¡dJfis Kbt¡yhj njhiyt¡y¡UeJ mgGss¡fF vLjJtu› Gw t¡ira¡dhy nraaggll NtiyfFr rkkhFk. vdNt q k¡dD}llk nfhzl Jfis Kbt¡yhj njhiyt¡y¡UeJ mgGss¡fF vLjJ tur nraaggLk NTiy›

W=qV

$W_Q = 2 \times 10^{-6} \times 5.06 \times 10^3$ J $= 10.12 \times 10^{-3}$ J.

vLj¡Jf¡fhl¡L 1.13

+qk¡dD}llk nfhzl Neuk¡dJfs M¡gGss¡a¡y itffgglLssJ. mj¡y¡UeJ 9mnjhiyt¡y ,dndhU Gss¡ k¡dJfs¡ 2q itffgglLssJ. ,kk¡dJfsfSfF ,ila¡y k¡ddOjjk Ro¡ahf css Gss¡iaf fzLg¡bffTk.

j¡uT

NkwnghUeJjy jjJtjj¡dgb› xU Gss¡a¡y cUthFk nkhjj k¡ddOjjkhdJ jd¡jjd¡ k¡dJfsfshy mgGss¡a¡y VwgLk k¡ddOjjqfs¡d $LjYfFr rkk.

nkhjj k¡ddOjj kj¡gG Ro¡ahFk Gss¡ +q k¡dJfs¡y¡UeJ x njhiyt¡y cssjhff fUjTk (glk)

Gss¡ P y nkhjj k¡ddOjjk Ro¡. ,ijg g¡dtUkhW vOjyhk.

$$V_{tot} = \frac{1}{4pe_o}\left[\frac{q}{x} - \frac{2q}{(9-x)}\right] = 0$$

$$\frac{q}{x} = \frac{2q}{(9-x)}$$

myyJ $\frac{1}{x} = \frac{2q}{(9-x)}$

vdNt› x= 3m

k¡d; ,UKidahy; xU Gs;s¡a¡y; VwgLk; e¡iy k¡d;dOj;jk

glk 1.26 ,y fhlbAssthW 2a vdw rwpa ,ilntspay gupffgglLss ,U rkkhd› Ntwpd kpdJfsfisf fUJNthk. kpd ,UKidapd eLgGsspyUeJ r njhiytpy P vdw Gsspcss J. AB vdw ,UKid mrRfFk OP vdw NfhlbwFk ,ilNTss Nfhzk *q* vdf.
+q tpyUeJ Gsspd njhiyT r_1 vdTk -q tpyUeJ Gsspd njhiyT r_2 vdTk nfhsf.

+q kpdJfspdhy Gsspy cUthFk

kpddOjjk= $\frac{1}{4pe_o}\frac{q}{r_1}$

-q kpdJfspdhy Gsspy cUthFk

kpddOjjk = $\frac{1}{4pe_o}\frac{q}{r_2}$

Gsspy cUthFk nkhjj kpddOjjk›

$$V=\frac{1}{4pe_o}q\left[\frac{1}{r_1}-\frac{1}{r_2}\right]$$

kpd ,UKidapyUeJ ntF njhiytpy Gsspd ,Uggpd.a<<r. vdNt rkdghLk (1.35) Ird rhugpy vOjyhk.
BOPKfNfhzjjpy nfhird tpjpiag gadgLjj.

$$r_1^2 = r^2 + a^2 - 2ra\cos q$$

$$r_1^2 = r^2\left[1+\frac{a^2}{r^2}-\frac{2a}{r}\cos q\right]$$

Gsspd kpd ,UKidapyUeJ ntF njhiytpy cssjhy a<<r. ,jdhy $\frac{a^2}{r^2}$,d kjpgG kpfTk rwpaJ. vdNt mijg Gwffzpffyhk. MfNt›

$$r_1^2 = r^2\left[1-2a\frac{\cos q}{r}\right]$$

(myyJ) $r_1 = r\left[1-\frac{2a}{r}\cos q\right]^{\frac{1}{2}}$

$$\frac{1}{r_1}=\frac{1}{r}\left[1-\frac{2a}{r}\cos q\right]^{\frac{1}{2}}$$

$\frac{a}{r}$ 1Mjyhy›<UWgGj Njwwjijg gadgLjjp cau mLfFfisg Gwffzpj J vOjpdhy›

$$\frac{1}{r}=\frac{1}{r}\left[1+\frac{a}{r}\cos q\right]$$

,NjNghy AOP KfNfhzjjpwF nfhird tpjpiag gadgLjj›

$r^2_2 = r^2 + a^2 - 2ra\cos(180-q)$

$\cos(180-q) = -\cos q$. Mjyhy

$r^2_2 = r^2 + a^2 + 2ra\cos q$

$\frac{a^2}{r^2}$ lg Gwffzpff

$$r_2^2 = r^2\left[1+\frac{2a\cos q}{r}\right]$$

$$r^2 = r\left[1+\frac{2a\cos q}{r}\right]^{\frac{1}{2}}$$

<UWgGj Njwwji jg gadgLjjpdhy>

$$\frac{1}{r^2} = \frac{1}{r}\left[1-a\frac{\cos q}{r}\right]$$

rkdghL (1.35) kwWk (1.36) Mfpatwiw rkdghL (1.35)y gpujpal

$$V = \frac{q}{4pe_o}\left[\frac{1}{r}\left(1+a\frac{\cos q}{r}\right) - \left(1+a\frac{\cos q}{r}\right) + \frac{1}{r}\left(1-a\frac{\cos q}{r}\right)\right]$$

$$V = \frac{q}{4pe_o}\left[\frac{1}{r}\left(1+a\frac{\cos q}{r}\right) - \left(1+a\frac{\cos q}{r}\right)\right]$$

$$V = \frac{1}{4pe_o}\frac{2aq}{r^2}\cos q$$

kpd ,UKidapd jpUgGjjpwd P= 2qa.vdNt>

$$V = \frac{1}{4pe_o}\left(\frac{P\cos q}{r^2}\right)$$

$P\cos q = P.r$ vd vOjyhk. ,qF r vdg JGsspO tpypUeJ Gsspy P I Nehffp css XuyF ntfluhFk. vdNt> kpd ,UKidahy xU Gsspapy cUthFk kpddOjjk

$$V = \frac{1}{4pe_o}\frac{P.r}{r^2} \qquad (r>>a)\ (1.38)$$

kpd ,UKidapd msit xggpLkNghJ kpf mjpfkhfTss njhiyTfSfF rkdghL (1.38) nghUeJk. Gsspy ,UKidfF vejj njhiytpwFk rkdghL (1.38) nghUeJk.

rpwgG NeuTfs;

NeuT (i) ,UKidapd mrRfNfhlby +q kpdJfs css gffjjpy Gsspy P ,Uejhy $q = 0^0$. mgNghJ kpddOjjk

$$V = \frac{1}{4pe_o}\frac{P}{r^2}$$

NeuT (ii) ,UKidapd mrRfNfhlby -q kpdJfs css gffjjpy Gsspy P ,Uejhy $q = 180^0$. vdNt

$$V = \frac{1}{4pe_o}\frac{P}{r^2}$$

NeuT (iii) ,UKidad eLtiufNfhlby Gsspd ,Uejhy› $q = 90^0$.vdNt $V = O$

Kf;fpa fUj;Jfs;

(i) kpd ,UKidad kpddOjjk $\frac{1}{r^2}$ vdwthW Fiwfpdwj; mNj rkak Gsspd kpdJfspd kpddOjjk $\frac{1}{r}$vdwthW Fiwfpdwj. vdNt xU Gsspd kpdJfistpl kpd ,UKidad Vnddwhy kpd ,UKidad kpddOjjk Ntfkhff Fiwfpdwj.Vnddwhy kpd ,UKidapypUeJ njhiyT mjpfupfFk NghJ Neu kwWk vjpu kpdJfsfspd NghJ Neu kwWk vjpu kpdJfsfspd tpisTfs xdiwnahdW rkdnraJ nfhsfpdwd.

(ii) Gsspd kpdJfs xdwpd kpddOjjk njhiyT rlg nghUjJ klLk cssikahy›V MdJ Nfhsr rkrru jdik nfhzLssJ. Mdhy kpd ,UKidapd kpddOjjk $\vec{P}$kwWk Gsspapd epiy ntflu $\vec{r}$ MfpatwWfF ,ilggll Nfhzjijr rhuej ,Uggjhy kpd ,UKidapd kpddOjjpwJF Nfhsr rkrru jdik ,yiy. ,UggpDk› ,UKidapd kpddOjjkhdJ mjd mrirg nghUjJ rkrru jdikAld cssJ. Nfhzjij (q) khwwhky›$\vec{P}$ ntfliug nghUjJ epiy ntflu $\vec{r}$Ir Rowwr nrajhy fpilfFk $kgpYss midjJ Gsspfsk xNu njhiytpy miktjhy xNu kpddOjjk cilad (glk 1.27). ,ggljjpy eyepw tisNfhlby css midjJ Gsspfsk XNu kpddOjjk cilad.

rk kpd;dOj;jg; gugG

Gwntspapy xU Gsspapy itffgglLss Gsspkpdjfs qit ikakhff nfhzl rMuKila fwgidf Nfhsjijf fUJNthk. (m) ,f Nfhsjjpd guggpYss midjJ Gsspfsk xNu kpddOjjk ngwwpUfFk. ,jjifa guggpidNa rk kpddOjjg gugG vdfpNwhk.

xU Gsspkpdjfspwf› rk kpddOjjg gugGfshf Xu ika Nfhsg gugGfs cssijg gljjpy (1.28 (M)) fhzyhk xtnthU Nfhsg gugGk xU rk kpddOjjg gugNg vdwhYk xtnthdwpd kpddOjjg gugNg vdwhYk xtnthdwpd kpddOjj kjpgGk nttNtW MFk.

vdgij czujJfpwJ. ,ej Ntiy kpddOjj NtWghlbwFr rkkhFk. vdNt›

$$dW = dV.$$

$$dW = -Edx$$

$$E = \frac{dV}{dx}$$

,jypUeJ› kpdGykhdJ vjpufFwpaplggll kpddOjjr rupTfF rkk vdwhfpwJ. NkNy css rkdghL (1.43) x- $WfF klLk nghUeJk. kpdGykhdJ %dW $WfSfFk nghJthf gpdtUkhW vOjggLfpwJ.

$$\vec{E} = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial z}\hat{k}\right)$$

Gsspkpdjfs jpushy cUthFk epiy kpddOjj Mwwy

q¹ Gss kdJfsyUeJ r njhiytYss xU Gssay kddOjjk MFk. ,gNghJ q² kdJfis Kbtyhj njhiytyUeJ q¹fF r njhiyty css Gssfhf vLjJtur nraaggLk NtiyahdJ mgGssay kddOjjk kwWk q² ,d ngUffwgyDfFr rkkhFk. vdNt›

$$W = q_2 V$$

,ej nraaggll NtiyahdJ r ,il ntsay mikeJss q_1 kwWk q_2 kdJfs mikggd eiykddOjj Mwwy UMf Nrkffgg Lfw J. MfNt

$$U = q_2 V = \frac{1}{4pe_o}\frac{q_1 q_2}{r}$$

,U kdJfsfSfF ,ilggll njhiyit ,ej eiy kddOjj MwwyhdJ rhueJssJ. q_1 eiyahfTk q_2 it Kbtyhj njhiytyUeJ efujj tUtjhf ,UejhYk› myyJ q_1 kwWk q_2 ,uz ilANk Kbtyhj njhiytyUeJ efujj tUtjhf ,UejhYk› myyJ $q_1$kwWk q_2 ,uz ilANk Kbtyhj njhiytyUeJ r ,ilntsay itggjhf ,UejhYk rkdghL nghUeJk.

%dW kdJfsfs gdtUkhWss eiyaikggy itffgglLssd (glk 1.30)

(i) q_1 kdJfSfF mUfy NtW vej kdJfsfSk njhlffjjy ,yyhjjhy Kbtyhj njhiytyUeJ mij Gss A tiu nfhzL tu vej NtiyAk nraaj Njitayiy.

(ii) q_2 kdgGila ,uzlhtJ kdJfis Gss BfF nfhzL tu q_1 cUthffa kdGyjjwF vjuhf Ntiy nraaggl NtzL q_2 d kJ nraaggLk NtiyW =q_2 B_{1B}.,qF V_{1B} vdgJ Kjy kdJfs q_1My Gss By VwgLk eiy kddOjjk

$$U = \frac{1}{4pe_o}\frac{q_1 q_2}{r_{12}}$$

q_2 it Kjyy nfhzL teJ gddu q_1 lf nfhzL tejhYk ,Nj rkdghNl filfFk vdgijf ftdffTk.

(iii) ,NjNghy› %dwhtJ kdJfs q_3l Gss CfF nfhzL tu q_2 kwWk q_3 kdJfsfs NrueJ cUthfFk nkhjj kdGyjjwF vjuhf Ntiy nraaggl NtzLk. vdNt. q_3 kdJfis efujjtur nraaggLk Ntiy = $q_3(V_{1C} + V_{2C})$. ,qF V_{1C} vdgJ Kjy kdJfs q_1 My Gss Cy VwgLk eiy kddOjjk kwWk V_{2C} vdgJ VwgLk eiy kdJfs q_2 y VwgLk eiy kddOjjk MFk. eiy kddOjj Mwwy

$$U = \frac{1}{4pe_o}\left(\frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right)$$

(iv) rkdghLfs (1.46) kwWk (1.47) lf $ll›$ q_1,q_2 kwWk q_3 ,twwhyhd kdJfs mikggdhy cUthffggLk nkhjj eiy kddOjj Mwwy.

$$U = \frac{1}{4\pi\varepsilon_o}\left(\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right)$$

Nrkïffggk eïiy kïddOjj Mwwy U MdJ mk%dW kïdJfsfisAk Fwïggïlggll Gssïfsïy eïiyeïWjjr nraaggLk NtiyfFr rkkhFk vdgijf ftdïffTk. mkkïdJfsfis vej vdgijf ftdïffTk. mkkïdJfsfis vej tuïiraïy vLjJ tejhYk ,Nj rkdghNl fïiljjïUfFk.

$Y}k tïir Xu Mwwy khwwh tïirahjyhy› kïdJfsfsïd eïiyaikgig fllikfFkNghJ cUthFk eïiy kïddOjj MwwyhdJ mttikgigf fllikfFk toïKiwiar rhueJ ,uhJ.

ruhd kïdGyjïjïy; csïs ,UKidaïd; eïiy kïdïdOjïj Mwïwy;

glk 1.31 y nfhLjJsssthW ruhd kïdGyk $\left(\vec{E}\right)$ xdwïy itffggllLss kïd ,UKidiaf fUJNthk. ruhd kïdGyjjïy itffggLk ,UKidaïd kJ xU jïUgGtïir nraygLk. ,jjïUgG tïirahdJ kïdGyjjïd jïiraïy ,UKidia xUqfikwffïdwJ.

kïdGyjjhy nrYjjggLk ,jjïUgG tïirfF vjïuhf njhlfff Nfhzk q ,yïUeJ ,Wjï Nfhzk q tiu (khwhj Nfhzj jïirNtfjJld) ,UKidia Royr nraa› kïdGyjjhy nfhLffggLk jïUgGtïirfF rkkhdJk vjïujjïiraïy cssJkhd Gwjjïugïtïir xdiw ,UKidaïd kJ nraygLjj NtzLk.

qNfhzjjïyïue J q Nfhzk tiu (khwhj Nfhzj jïirNtfjJld) ,UKidia Royr nraa Gwjjïugï tïirahy nraaggLk Ntiy

$$W = \int_{q'}^{q} \tau_{ext}\, dq$$

$\vec{t}_E = \vec{P} \times \vec{E}$ fF rkkhfTk vjïhjjïiraïYk $\vec{t}_{ext}$ cssjhy›

$$\left|\vec{t}_{ext}\right| = \left|\vec{t}_{E}\right| = \left|\vec{P} \times \vec{E}\right|$$

$$W = \int_{q'}^{q} pE \sin q\, dq$$

$$W = pE\,(\cos\theta' - \cos\theta)$$

,ej Ntiyahdj Nfhz eïiyfs θkwWk θ' fF ,ilNaAss kïddOjj Mwwy Ntwghlfr rkkhFk.

$$U(\theta) - U(\theta') = \Delta U = -pE\cos\theta + pE\cos\theta'$$

njhlfff Nfhzk vdWk ,ijNa RlLgGssïahfTk (reference point) vLjJfnfhzlhy

$$U(\theta') = pE\cos 90° = 0$$

vdNt ruhd kïdGyjjïy itffggllLss ,UKid mikgG xdwïy Nrkïffggk kïddOjj Mwwy

$$U = -pE\cos\theta = \vec{p}.\vec{E}$$

p kwWk E lj jtïu kïddOjj MwwyhdJ Gw kïdGyjijg nghWjj kïd ,UKidaïd jïiraikgigAk rhhejïUfFk. Gw kïdGyjJfF vjïhïizahf ($q = p$) ,UKidj jïUgGjjïwd mikAkNghJ kïddOjj Mwwy ngUkkhfTk

Gwk¡dGyjJfF ,izahf (θ = 0°) ,UKidj j¡UgGjj¡wd mikAk NghJ k¡ddOjj Mwwy r¡WkkhfTk ,UfFk.

vLj¡Jf¡fhl¡L:

eh %yf$W xdw¡d k¡d ,UKidj j¡UgGjj¡wd 6.3×10^{-30} cm. 10^{22}eh %yf$Wfisf nfhzl khj¡h¡ (sample) xdw¡Yss midjJ ,UKidj j¡UgGjj¡wdfSk vzkj¡gG 3×10^{5} NC^{-1}nfhzl Gw k¡dGyjJld xUqfikeJssd. midjJ eh %yf$WfisAk θ= 0°y¡UeJ 90°fF Royr nraa NjitggLk Ntiy vttsT?

jh¡T:

midjJ eh %yf$WfSk k¡dGyjj¡d j¡iray mikeJssjhy› mit r¡Wk k¡ddOjj Mwwiyg ngww¡UfFk. θ = 0°y¡UeJ 90° tiu ,UKidia Roww nraaggLk NtiyahdJ ,tt¡U e¡iyaikgGfSfF ,ilNaahd k¡ddOjj Mwwy NtWghlLfFr rkkhFk.

$$W = \Delta U = U(90°) - U(0°)$$

rkdghL ,y¡UeJ›U = - pE cosθvd vOjyhk. g¡wF xU eh %yf$iw = θ = 0°Kjy 90° tiu Roww nraaggLk Ntiyiaf fzff¡lyhk.

$$W = -pE\cos 90° + pE\cos 0° = pE$$

xU eh %yf$WfF

$$W = 6.3 \times 10^{-30} \times 3 \times 10^{5} = 18.9 \times 10^{-25}\ J$$

10^{22}eh %yf$WfSfF› nraaggLk nkhjj Ntiy

$$W_{tot} = 18.9 \times 10^{-25} \times 10^{22} = 18.9 \times 10^{-3}\ J$$

fh]; tj¡Ak; mjd; gadghLfSk;:

k¡dghak; (Electric Flux):

k¡dGyf NfhLfSfFf FWfNf mikej Fw¡ggll gugG xdw¡d to¡Na ghAk k¡dGyf NfhLfs¡d vzz¡fif k¡dghak vdggLk. ,ij $F_E$vdw f¡Nuff vOjj¡dhy Fw¡gNghk. NkYk ,jd myF $N\,m^2\,C^{-1}$. k¡dghak xU]Nfyh msT MFk. NkYk ,J NehfFw¡ myyJ vj¡hfFw¡ kj¡gigg ngwW ,UfFk. k¡dghak vdwhy vdd vdgij vs¡j¡y Gh¡eJ nfhss gadgLk.

,ggljj¡y Gss¡ k¡dJfs xdw¡d k¡dGyk fhllgglLssJ. A kwWk B Mf¡a gFj¡fs¡y Gyjj¡wF nrqFjjhf mikeJss ,U r¡w¡a nrttf – tbtg gugGfisf fUJNthk. ,tt¡U gugGfSk xNu guggsitf nfhzbUejhYk gFj¡ A t¡y css nrttfjijf flfFk k¡dGyf NfhLfs¡d vzz¡fif gFj¡ B ,y css nrttfjijf flfFk k¡dGyf NfhLfis t¡l mj¡fkhf cssJ. njhiyT mj¡fh¡fFk NghJ Gss¡ k¡dJfs xdw¡d k¡dGy ty¡ik Fiwtijg Nghy njhiyT mj¡fh¡fFkNghJ mjd k¡dghaKk Fiwf¡dwJ. ,Jtiu ehk ghhjj fUjJfs k¡dghajijg gww¡a xU gzGrhh vzzjij (Qualitative idea) cUthff cjTk. vd¡Dk› k¡dghajj¡d Jyy¡akhd tiuaiw NjitggLf¡wJ.

ruhd k¡dGyj¡j¡d; k¡dghak;:

Gwntsa¡y xU gFj¡a¡y e¡yTk ruhd k¡dGyjijf fUJNthk. nfhLjJssgb k¡dGyf NfhLfSfFf nrqFjjhf css gugG A it vLjJf nfhsNthk. ,ej NehTfF k¡dghak

$$F_E = EA$$

ruhd ,kk¡dGyjj¡wF ,izahf gugG A it itjjhy› mggugg¡d csNs ghAk k¡dGyf NfhLfs RoahFk ,ej Neht¡y k¡dghak.

$$F_E = 0$$

gugGld θ Nfhzjij kdGyk cUthfFkNghJ guggwF nrqFjjhd jiray css kdGyf$W klLNk kdghajij msffwJ. guggwF ,izahfTss kdGyf$W kdghajij msggjyiy. ,ej Nehtiy kdghak

$$F_E = (E\cos q)A$$

,qF kdGyjjd jirfFk guggwF tiuaggLk nrqFjJf Nfhlbd jirfFk ,ilNaAss Nfhz Nk θ. vdNt› nghJthd tiuaiwahf› ruhd kdGyjjd kdghak gdtUkhW tiuaWffggLfwJ.

$$F_E = \vec{E}.\vec{A}. = EA\cos q$$

,qF $\vec{A} = A\hat{n}$ vdgijf ftdffTk. ,jd vzkjgG A kwWk ,jd guggwF nrqFjJ jiraiYss XuyF ntflh $\hat{n}$. ,ej tiuaiwaid gb› $F_E = \vec{E}.\vec{A}.$ NkYk kwWk Mfia rkdghLfis ,jd rwgG NehTfshf ngw KbAk.

(m) tiy› $q = 0°$. vdNt $F_E = \vec{E}.\vec{A}. = EA$

(M) tiy› $q = 90°$. vdNt $F_E = \vec{E}.\vec{A}. = 0$

vLjJf¡fhl¡L:

100 N C^{-1} kjgGila ruhd kdGyk eiyTk gFjaiy itffgglLss 5 cm kwWk 10 cm gffqfs nfhzl nrttfjijf flfFk kdghajijf fzffiLf. nfhLffggll Nfhzk θ = 60°. xUNtis θRoi vdi› kdgak vdd?

jhT:

kdghak

$$F_E = \vec{E}.\vec{A} = EA\cos q = 100 \times 5 \times 10 \times 10^{-4} \times \cos 60°$$

Þ $F_E = 0.25 Nm^2 C^{-1}$

$q = 0°$ vdiy

$$F_E = \vec{E}.\vec{A} = EA = 100 \times 5 \times 10 \times 10^{-4} = 0.5 Nm^2 C^{-1}$$

ruww kdGyk kwWk VNjDk xU tbtKss guggwF kdghak

ruww kdGyk kwWk jlilahf ,yyhj tis gugG A mfiatwiwf fUJNthk. ,jd nkhjj guggsitAk $D\vec{A}_1, D\vec{A}_2, D\vec{A}_3, \ldots\ldots D\vec{A}_n$ Mfia n kfrrwia gugGf $Wfshfg ghijNjhk vdwhy xtnthU gugGf $iwAk filjjll jlilahf cssjhfTk xtnthU gugGf $wid toiahff flfFk kdGyKk ruhf cssjhfTk fUjyhk.

nkhjj guggsT AfFkhd kdghajijj Njuhakhf vOjdhy

$$F_E = \vec{E}_1.D\vec{A}_1 + \vec{E}_2.D\vec{A}_2 + \vec{E}_3.D\vec{A}_3, \ldots\ldots\ldots \vec{E}_n.D\vec{A}_n$$

$$= \sum_{i=1}^{n} \vec{E}_i.D\vec{A}_i$$

(midjJ ikjgGfSfFk) $D\vec{A}_i \to 0$ vdw vyiyia itjNjhk vdwhy rkdghL ,y css $lLjnjhifahdJ njhifaiyhf khWk. ,gNghJ› KO guggwFkhd nkhjj kdghak.

$$F_E = \int \vec{E}.d\vec{A}$$

rkdghL yiUeJ xU Fwiggll guggwfhd kdghakhdJ mjd Gwgguggid toiNa nryYk kdGyjijAk kdGyjijg nghUjJ guggid jiraikgigAk rhhejiUfFk vdgJ njsithfwJ.

%ba gugGfSfF kdghak:

nrdw gh‌t‌y› VNjDk xU tbtKss tisgugg‌wFh‌a k‌dghajijg gww‌ mw‌eNjhk. nfhLjJssthW ruww k‌dGyk css gFj‌a‌y xU %ba gugG cssjhff fUJNthk. ,k%ba gugg‌wfhd k‌dghak

$$F_E = \oint \vec{E}.d\vec{A}$$

rkdghL kwWk rkdghL ,ila‌yhd NtWghlilf ftd‌ffTk. rkdghL y gadgLjjgglLss njhifa‌lyhdJ xU %lggll myyJ %ba gugGj njhifa‌lyhFk NkYk mj‌Yss xtnthU gugGf $WfFk tiuaggLk nts‌Nehff‌a nrqFjJf Nfhlh $d\vec{A}$d j‌irahFk.

xU %ba gugg‌d nkhjj k‌dghakhdJ NehfFw› vj‌hfFw‌ myyJ Ro‌ kj‌gigg ngww‌UfFk.

xU gugGf$W $d\vec{A}$k‌dGyk $\vec{E}$Ald cUthfFk Nfhzk I t‌lf Fiwthf cssjhy mjd k‌dghak NehfFw‌ kj‌gG cilajhfTk ,dndhU gugGf$W $d\vec{A}$k‌dGyjJld cUthfFk Nfhzk 90° I t‌l mj‌fkhf cssjhy mjd k‌dghak vj‌hfFw‌ kj‌gGilajhfTk cssd.

nghJthf› %ba gugg‌Ds k‌dGyf NfhLfs Eioejhy k‌dghak vj‌hfFw‌ vdTk %ba gugig t‌lL mit nts‌Naw‌dhy k‌dghak NehfFw‌ vdTk nfhssyhk.

fh]; t‌j‌ (Gauss law):

Q k‌ddD}ll kj‌gGilanthU Gss‌ k‌dJfisr Rww‌ r Muk nfhzl fwgidf Nfhsk (imaginary sphere) xdW fhllgglLssJ. mjd %ba gugg‌d to‌Na nts‌Nehff‌a j‌ira‌y flfFk nkhjj k‌dghaj‌j‌id rkdghL %yk ehk fzff‌lyhk.

$$F_E = \oint \vec{E}.d\vec{A} = \oint EdA\cos q$$

,gGss‌ Neh k‌dJfs‌d k‌dGykhdJ Nfhsg gugg‌d xtnthU Gss‌a‌Yk Mu to‌Na nts‌Nehff‌a j‌ira‌y mikf‌dwJ. vdNt› gugGf$W $d\vec{A}$MdJ k‌dGyjj‌d j‌ira‌NyNa cssjhy $q=0°$

$$F_E = \oint EdA \text{ Vnddy } \cos 0° = 1$$

Nfhsjj‌d gugg‌y E ruhf cssjhy

$$F_E = E\oint dA$$

$\oint dA = 4pr^2$ kwWk $E = \frac{1}{4pe_0}\frac{Q}{r^2}$ rkdghL y guj‌a‌l›

$$F_E = \frac{1}{4pe_o}\frac{Q}{r^2}, 4pr^2 = 4p\frac{1}{4pe_o}Q$$

$$F_E = \frac{Q}{e_o}$$

rkdghL fh] t‌j‌ vdggLk. ,ej Kbt‌d Fw‌gg‌ljjff gzG vddntdwhy k‌dJfis %bAss gugG vjjifa tbtk nfhzbUejhYk mjwF rkdghL nghUeJk. S_1, S_2kwWk S_3 Mf‌a %dW %ba gugGf SfFk nkhjj k‌dghak xdNw vdgij ftd‌ffTk.

VNjDk xU tbtKss (Arbitrary) %ba gugg‌dhy Q k‌ddD}llk nfhzl xU k‌dJfs #ogglbUgg‌d mk%baggugg‌wfhd nkhjj k‌dghakhdJ

$$F_E = \oint \vec{E}.d\vec{A} = \frac{Q_{cs}}{e_o}$$

,JNt fh] tpjpad $wW. ,qF Q_{cs} vdgJ %ba guggpwF csNs mikeJss kpdJfsfspd nkhjj kpdD}llkhFk.

fh]; tpjp – xU fyepjhaT:

1. #oeJss guggpidf flfFk nkhjj kpdghakhdJ mgguggpdhy #ogglLss kpdJfsfis klLNk rhhejpUfFk. khwhf› mggugGfF ntspNa mikeJss kpdJfsfs kpdghajijf nfhLffhJ. NkYk› kpdJfsfis #Ok gugig vejnthU tbtjjpYk (Arbitrary) ehk njhpT nraJ nfhssyhk.

2. nkhjj kpdgha kjpgghdJ #Ok guggpwFsNs mikeJss kpdJfsfspd miktpljij (location) rhhejpUffhJ.

3. rkdghL ngWtjwF ehk Nfhsfg gugigg gadgLjjp csNshk. ,ej fwgidg guggpidNa fh]pad guggpidNa fh]pad gugG (Gaussian Surface) vdgh. kpdJfs epiyaikggpd tif (Type of charge configuration) kwWk kpdJfs epiyaikggpd rkrrh jdik (symmetry in configuration) Mfpait rhheNj ehk njhpT nraAk fh]pad guggpd tbtk ,Uff NtzLk. xU Gsspkpd kpdJfspd kpdGykhdJ Nfhsfr rkrrh jdik nfhzLssjhy Nfhsf tbtf fh]pad gugigf njhpT nraNjhk. gpw tifggll kpdJfs epiyaikgGfSfF cUis tbt kwWk rkjs tbt fh]pad gugGfisj NjhenjLffyhk.

4. rkdghL ,d ,lJif gffjjpy nfhLffgglLss kpdGyk $\vec{E}$ MdJ fh]pad guggpwF csNsAk ntspNaAk mikeJss kpdJfsfshy cUthFkkpdGyjijf Fwpggjhf ,UejhYk fh]pad guggpwF csNs mikeJss kpdJfsfspd nkhjj kpdD}ll kjpgig klLNk Q_{cs} Fwpffpdwj.

5. vejnthU jdpjj kpdJfspd ClhfTk fh]pad gugG fleJ nryyhJ. Mdhy kpdJfs njhlh gutyfspd (continuous charge distribution) CNl mJ fleJ nryYk. Vnddpy› jdpjj kpdJfsfSfF kpf mUfpy› kpdGyjij Jyypakhf tiuaWff ,ayhJ.

6. $Y}k tpjpad ,dndhU tbtNk fh] tpjp. NkYk ,affjjpYss kpdJfsfSfFk fh] tpjpiag gadgLjjyhk. ,jdhy jhd› $Y}k tpjpia tpl nghJthd tpjpahf fh] tpjp ghhffggLfpwJ.

fh]; tpjpad; gadghLfs;:

VNjDk xU tbtKss kpdJfs njhFjpfSfF kpdGyjijf fzffpl $Y}k tpjp myyJ fh] tpjpiag gadgLjjyhk. kpdJfs mikgG VNjDnkhU rkrrh jdikiag ngwwpUejhy kpdGyjijf fzffpl fh] tpjpNa kpfrrpwej topahFk. gpdtUk NehTfspy ,ijf fhzyhk.

1. kpdD}llk ngww Kbtpyh esk cila fkgpapdhy VwgLk kpdGyk

   λ vDk ruhd kpdD}ll es mlhjjp nfhzl Kbtpyh esKila fkgpiaf fUJNthk. fkgpapypUeJ rnrqFjJj njhiytpy Gsspy PcssJ. fh] tpjpiag gadgLjjp P,y cUthFk kpdGyjijf fzffplyhk.

   Gsspy P,ypUeJ rk njhiytpy› fkgpapy mikeJss ,U rpwpa kpdJfs $Wfis vLjJfnfhsNthk ,ttpU kpdJfs $Wfspdhy cUthFk njhFgad

kjdGykhdJ kjdD}llk ngww fkgjayjUeJ Mu tojNa ntsjNehffja jjiirajy mikfjdwJ. NkYk›r MuKila tlljjjd midjJg Gssjfsjyk mjd vzkjjgG rkkhf ,UfFk. ,J tjy fhllgglLssJ. ,ejg gzgjd mbggilajy kjdD}llk ngww fkgj cUis tbt rkrrh jdik cilaJ vdyhk. vdNt r MuKk LesKk nfhzl cUis tbt fhjjad gugigf fUJNthk.

,ggugjgwfhd nkhjj kjdghajij gjdtUkhW fzffjlyhk.

$$F_E = \oint \vec{E}.d\vec{A}$$

$$= \int_{\text{tis gugG}} \vec{E}.d\vec{A} + \int_{\text{Nkw gugG}} \vec{E}.d\vec{A} + \int_{\text{mbg gugG}} \vec{E}.d\vec{A}$$

tisggugjgy $\vec{E}$ MdJ $\vec{A}$ fF ,izahf cssjhy $\vec{E}.d\vec{A} = E\,dA$.

Nky kwWk mbggugGfSfF $\vec{E}$ MdJ $\vec{A}$ tjwF nrqFjjhf cssjhy› $\vec{E}.d\vec{A} = 0$

,kkjjgGfis rkdghL gjujajlL fhj] tjjia cUis tbt gugjgwFg gadgLjjjdhy

$$F_E = \int_{\text{tis gugG}} EdA = \frac{Q_{cs}}{e_0}$$

nkhjj tis gugigg nghUjjtiu kjdGyjjjd vz kjjgG khwjyjahf cssjhy›E MdJ njhifajly FwjalLfF ntsjNa vLffggLfjwJ. NkYk $Q_{cs} = /L$ vdg gjujajl›

$$E = \int_{\text{tis gugG}} dA = \frac{/L}{e_0}$$

,qF $F_E = \int_{\text{tis gugG}} dA =$ tisgugjgd nkhjj gugG $= 2prL$

,ij rkdghL gjujajl› $E.2prL = \frac{/L}{e_o}$

$$E = \frac{1}{2pe_o}\frac{/}{r}$$

ntflh tbtjy› $\vec{E} = \frac{1}{2pe_o}\frac{/}{r}\hat{r}$

$$E.2prL = \frac{/L}{e_o}$$

Gssj kjdJfs xdwjd kjdGyk $\frac{1}{r^2}$ vdwthW ,Uggij mwjNthk. khwhf kjdD}llk ngww Kbtjyh esKila fkgjajd kjdGyk $\frac{1}{r}$ vdwthW mikeJssJ.

fkgjfF nrqFjjhd jjiirajNyNa (r') kjdGyk vgNghJk mikeJssJ vdgij rkdghL %yk mwja KbfwJ. NkYk λ > 0 vdjy› fkgjfF

nrqFjjhf ntsNehffa jiray $\vec{E}$,UfFk; $\lambda < 0$ vdy> csNehffa jiray $(-r)$ nrqFjjhf $\vec{E}$,UfFk.

Kbtyh esKss kdD}llk ngww fkgfF klLNk rkdghL nghUeJk. tukgwFlgll esKss kdD}llk ngww fkgiag nghUjjtiu kdGykhdJ midjJ Gssfsyk Mujjiray miktjyiy. ,Uggdk> mjjifa fkgad ikagGssfF mUfyk fkgad Kidfsyuej ntF njhiytyss GssfSfFk rkdghL gadgLjjyhk.

1. kdD}llk ngww Kbtyh rkjsj jlbdhy cUthFk kdGyk

σ vDk ruhd kdD}llg guggllhjjp nfhzl Kbtyh rkjsjjlL xdiwf fUJNthk. mjjlbyUeJ r njhiytyy Pvdw Gssp cssJ.

rkjsjjpd msT Kbtyhjj vdgjhy> mjpyUeJ rk njhiytpy css midjJ Gsspfsyk kdGyjjpd kjpgG rkkhf ,UfFk. midjJ Gsspfsyk kdGyjjpd jpir Mu topNa mikejUfFk. 2r esKk A FWfFntlLg gugG nfhzl cUis tbt fhjpad gugigf fUJNthk; mjd eLggFjp topahf Kbtyh rkjsjjlL flggjhff nfhsNthk. ,tTUis tbt gugGfF fhj tjpiag gadgLjjpdhy

$$F_E = \oint_P \vec{E}.d\vec{A}$$

$$= = \int_{\substack{tis\\ gugG}} \vec{E}.d\vec{A} + \oint_P \vec{E}.d\vec{A} + \oint_{P'} \vec{E}.d\vec{A} = \frac{Q_{cs}}{e_o}$$

tisgugGd NkYss midjJ Gsspfsyk kdGykhdJ guggsTf $WfSfF nrqFjjhfTk PkwWk P'gugGfspy mJ ,izahfTk ,UffwJ.

$$F_E = \oint_P EdA + \oint_{P'} EdA = \frac{Q_{cs}}{e_o}$$

,ttpU gugGfSfFk kdGyjjpd vz kjpgG ruhf cssjhy njhifapLy FwpalLfF ntspNa EvLffggLfwJ. NkYk $Q_{cs} = sA$ vdNt

PmyyJ P'gugGd nkhjj guggsT

$$\oint_P dA = A$$

$$2EA = \frac{sA}{e_o} \text{ myyJ } \quad E = \frac{s}{2e_o}$$

ntflh tbtpy> $\vec{E} = \frac{s}{2e_o}\hat{n}$

,qF $\hat{n}$ vdgJ rkjsjjwF nrqFjjhf> ntspNehffpa jpirapYss XuyF ntfluhFk. kdD}llk ngww Kbtyh rkjsjjlbdhy cUthFk kdGykhdJ kdD}ll gugGlhjjpiaj rhheJk mNjrkak njhiyitr rhuhkYk rhuhkYk ,Uffpdwj.

kdD}llk ngwwj jlbyUeJ fzprkhd njhiytpYss vejnthU Gsspapyk kdGyk rkkhf ,UfFk. $\sigma > 0$ vdpy vejnthU Gsspapyk (P) kdGykhdJ (jlbd) jsjjpwF nrqFjjhf> ntspNehffpa jpirapYk ($\hat{n}$), $\sigma < 0$ vdpy kdGykhdJ jsjjpwF nrqFjjhf kdD}llk ngwwj jlbyUeJ csNehffpa jpirapYk ($-\hat{n}$) ,UfFk vdgij %yk mwpayhk.

tukgwFlgll guggsitf nfhzl kdD}llk ngww rkjsj jlilg nghUjjtiu jlbd eLggFjay rkdghL XusT nghUeJk. NkYk mjd Kidfsy UeJ ntFnjhiytYss Gssf SfFk ,rrkdghL nghUeJk.

kd;D}l;lk; ngww ,U ,izahd Kbtyh jl;Lfsdhy; cUthFk; kdGyk;

+σkwWk -σvdfw kdD}llg guggIhjj nfhzl ,U Kbtyh kdD}llk ngww rkjs jlLfisf fUJNthk. ,y fhlbagb mit xdWfnfhdW ,izahf cssd.

jlLfSfF ,ilNaAk› jlLfSfF ntsaYk cUthFk kdGyjij fh] tjiag gadgLjj fzLgbffyhk. kdD}llk ngww Kbtyh rkjsj jlbd kdGy kjgG $\frac{s}{2e_o}$ NkYk σ> 0 vdy mJ nrqFjjhf› ntsNehffa jiraYk σ< 0 vdy mJ (nrqFjjhf) csNehffa jiraYk ,UfFk.

P_2kwWk P_3Mfa Gssfsy ,U jlLfsdhy VwgLk kdGyqfsd vz kjgG rkkhfTk vjnujh jir cilajhfTk cssd. vdNt› jlLfSfF ntsNa css Gssfsy kdGyk RoahFk. Mdhy jlLfSfF ,ilNa css Gssfsy (P_1) mtwwd kdGyqfs xNu jiray. mjhtJ tyJ jir Nehff miktjhy›

$$E_{cs} = \frac{s}{2e_o} + \frac{s}{2e_o} + \frac{s}{2e_o} = \frac{s}{e_o}$$

jlLfSfF ,ilNa kdGykhdJ Neh kdD}llk ngwwj jlbyUeJ vjh kdD}llk ngwwj jlil Nehffa jiraYUfFk. NkYk jlLfSfF ,ilay css midjJg Gssfsyk kdGyk ruhf ,UfFk.

kd;D}l;lk; ngww cs;slww Nfhsj;jdhy; cUthFk; kdGyk;

R MuKk Q kdD}llKk nfhzl› ruhd kdJfs guty ngww csslww Nfhsk xdiwf fUJNthk fh] tjiag gadgLjj NfhsjjwF ntsNaAk csNsAk css Gssfsy kdGyjijf fzffiyhk.

NehT (m) NfhsjjwF ntsay css Gssay (r > R) Nfhsjjd ikajjyUeJ r njhiytY› Nfhsjjd ntsNa css Gss lf fUJNthk. kdJfsfs Nfhsjjd Gwggugg ruhfg gutAssd (Nfhsfr rkrrh jdik). MfNt Q > 0 vdy kdGyk Mu toNa ntsNehffa jiraYk Q < 0 vdy Mu toNa csNehffa jiraYk ,UffwJ. rMuk nfhzl Nfhs tbt fh]ad gugg idf fUJNthk. ,ggugg dhy #oggLk kdJfsfsd nkhjj kdD}llk Q vdf. fh] tjiag gadgLjj

$$\oint_{\text{gugG fh]ad}} \vec{E}.d\vec{A} = \frac{Q}{e_o}$$

fh]ad gugg d midjJ Gssfsyk kdGyKk $\left(\vec{E}\right)$ guggsTf$Wk $\left(d\vec{A}\right)$ xNu jiray (ntsNehffa jiray› nrqFjjhf) mikfdwd. kdJfs eiyaikgg d Nfhsfr rkrrh jdikahy fh]adgugg y css midjJ Gssfsyk d vzkjgGk rkkhfNt ,UfFk.

vdNt $E \oint_{\text{gugG fh]ad}} dA\frac{Q}{e_o}$

Mdhy $\oint dA$ fh]ad gugg d nkhjj guggsT = $4\pi r^2$,ij rkdghL gujal›

$$E.4pr^2 = \frac{Q}{e_o}$$

$$E.4pr^2 = \frac{Q}{e_o} \text{ myyJ } \quad E = \frac{1}{4pe_o}\frac{Q}{r^2}$$

ntflh tbtpy $\vec{E} = \frac{1}{4pe_o}\frac{Q}{r^2}\hat{r}$

Q - 0 vdpy kpdGykhdJ Mu topNa ntspNehffpa jpirapYk›Q < 0 vdpy Mutopna csNehffpa jpirapYk mikAk. Nfhsjjpwf ntspNa css Gsspfisg nghUjj tiu› csslww Nfhsjjpd ikajjpy Q kpdD}llk nfhzl xU Gsspy kpdJfis itjjhy vtthW kpdGyk mikANkh mtthW Nfhsjjpd kpdGykhdJ mikfpwJ. (<hggpaypy ,Nj Nghdwnjhu Kbit›M epiw nfhzl csslww Nfhsjjpdhy VwgLk <hgg tpiriaj jUtpfFk NghJ ngwwij epidtpy nfhssTk)

NehT (M): Nfhsjjpd Gwggugg py css Gsspapy (r = R)

Nfhsff $lbd Gwggugg py css GsspfSfF (r = R) kpdGykhdJ.

$$\vec{E} = \frac{Q}{4pe_oR^2}\hat{r}$$

NehT (,): Nfhsjjpwf csNsAss Gsspay (r < R)

Nfhsfjjpd ikajjpypUeJ r njhiytpy› Nfhsjjpwf csNsAss Gsspy P lf fUJNthk. rMuk nfhzl Nfhs tbt fh]pad gugG xdiw tiuNthk.

$$\oint_{\text{fh]pad gugG}} \vec{E}.d\vec{A} = \frac{Q}{e_o}$$

$$E.4pr^2 = \frac{Q}{e_o}$$

,ej fh]pad gugGfFsNs vej xU kpdJfSk ,yyhjjhy Q = 0 vdNt› rkdghL gb

E = 0 (r < R)

Nkwgugg pd kJ kpdJfsfs ruhf gutg ngww csslww Nfhsjjpd csNs mikeJss midjJ GsspfSfFk kpdGyk Ropna. MujnjhiyTfFk (radial distance) kpdJfsfs ruhd guty ngww csslww Nfhsjjpd kpdGyjjpwFk ,ilNaahd fhllgglLssJ.

Fwpggpllnthu kpdJfs epiyaikgghdJ Nfhsf› cUis myyJ rkjs rkrrh jdik nfhzbUfFk NghJ mjjifa kpdJfs mikgGfspd kpdGyjij vspjpy fzlwpa fh] tpjp xU rpwej topKiwahFk. mjjifa rkrrh jdik mikahj epiyapy Neubahd topKiwiaNa ($Y}k tpjpAk Ezfzpjkk) gpdgww NtzLk. vLjJffhllhf› kpd ,UKidapd kpdGyjijf fzlwpa fh] tpjpiag gadgLjJtJ fbdk. Vnddpy› mjwF NkNy Fwpggpll vejnthU rkrrh jdikAk fpilahJ.

fljjpfs; kwWk; kpd;fhgGfspd; epiy kpd;dpay; gz;Gfs; epiykpd; rkepiyapy; fljjpfs;

xU kpdfljjpg nghUspy fllwW Rjejpukhf ,aqFk kpdJfsfs Vuhskhd vz zpfifapy cssd. xU cNyhff fljjpapy css ,aqFk kpdJfsfs flLwh vyfluhdfNs MFk. vej mZNthLk mit fllgglt pyiy. vdNt fljjpapd guggpy mtwwhy vsjhf mqFk ,qFk nryy Kbfpdwj. Gw kpdGyk mspffgglhj NghJ› xOqfpyyhky midjJ jpirfspYk njhlheJ mit ,affjjpy ,Uffpdwd. ,jd tpisthf› vejnthU Fwpggpll jpiria NehffpAk

vyfluhdfsd efu ,affk ,yyhjjhy mffljj eiykd rkeiyay ,UffdwJ. vdNt› eiykd rkeiyaYss fljjay vttj efu kdNdhllKk (net current) ,Uggjyiy. ,rrkeiyaYss xU fljjfF gdtUk gzGfs cssd.

1. fljjad clGwjjyUfFk midjJ GssfsYk kdGyk RoahFk. ,f$wW jzkf fljj kwWk csslww $L tiff fljj ,uzbwF nghUeJk.

   ,J Matd mbggilay ehk fzlwej czik. xU Ntis fljjad clGwjjy kdGyk Roayy vdwhy mqNfAss flLwh vyfluhdfs kJ tir nraygl NtzLk myyth? ,jd tisthf› mit (flLwh vyfluhdfs myyJ ,aqF kdJfsfs) xU Fwggll jiria Nehff efu ,affjiijg ngWk. ,J eiykd rkeiyaYss fljjfsd jdikfF khwhdnjhU eiyahFk. vdNt› fljjad clGwjjy midjJ GssfsYk kdGyk RoahfNt ,Uff NtzLk. ruhd Gw kdGyjij fljjad kJ nraygLjjAk ,tTzikiag GheJ nfhssyhk.

   Gw kdGyjij nraygLjJk Kd fljjaYss flLwh vyfluhdfs fljj KOtjYk ruhfg gutaUfFk. kdGyjij nraygLjJk NghJ› ,lfifg gffk mit KLffggLtjhy ,lJgffj jfL vjh kdD}llKk tyJgffj jfL Neh kdD}llKk ngWfdwd flLwh vyfluhdfs ,tthW ksiktjhy (realign) fljjad clGwk mf kdGyk cUthfdwJ. Gw kdGyjij rkdnraAk tiu ,J mjfhffdwJ. Gw kdGyk rkdnraaggll gdG fljj eiykd rkeiyaYssjhff fUjggLfwJ. ,rrkeiyia mila xU fljj vLjJfnfhsSk Neuk VwfFiwa 10^{-16}s. vdNt ,ij Xh cldb efothfNt fUjyhk.

2. fljjad clGwjjy css kdJfsfsd efu kdD}llk Ro. fljjfsd Gwgguggy klLNk kdJfsfs ,Uff KbAk.
   fljjad clGwjjy midjJ GssfsYk kdGyk Roahjyhy fh]ad guggidf flfFk efu kdghaKk RoahfNt ,UfFk. vdNt fh] tjad gb› fljjad clGwk ,UfFk efu kdD}ll kjgGk Ro vdgijNa ,J czhjJfwJ. Ntis ry kdJfsfis fljjad clGwk ,UjjdhYk clNdNa mit fljjad gugig mileJ tLk.

3. fljjfF ntsNa kdGykhdJ mjd gugGfF nrqFjjhfTk vz $\frac{s}{e_o}$ kjgG nfhzljhfTk ,UfFk. ,qF σvdgJ fljjad Fwggll gFjay css kdD}llg guggl hjj MFk.

   fljjad guggwF ,izahd jirfsy kdGyjjd $Wfs ,Uejhy guggYss flLwh vyfluhdfs KLffggLk mjhtJ› fljj rkeiyay ,yiy vdwhFk. vdNt› eiykd rkeiyay› fljjad gugGfF nrqFjjhd jiray klLNk kdGyk mikAk.

   fjjad gugGfF rwW ntsNa kdGyjjd vzkjgG $\frac{s}{e_o}$ vdgij eWTNthk. rwa cUis tbt fh]ad gugigf fUJNthk. ,tTUisad xU ghj fljjad clGwkhfg gjeJssJ.

fljjad gugGfF nrqFjjhf kdGyjjd jir ,UfFk vdgjhy› cUisad tisguggidf flfFk kdghak Ro. NkYk fljjad clGwk kdGyk Roahtjhy fh]ad guggd mbgghjfF kdghak Ro.

vdNt› Nkygff jlilg gugG klLNk kdghajijf nfhLfFk. ,jy kdGyjjd jirahdJ gugG $\left(\overset{u}{A}\right)$ntflhd jiraNyNa ,UfFk. NkYk (Nkwghj cUis) guggwF clGwk css kdJfsfsd nkhjj kddD}ll kjgG σA. fh] tjiag gadgLjj›

$$EA = \frac{sA}{e_o}$$

ntflh tbtiy› $\overset{ur}{E} = \frac{s}{e_o}$ $\hat{n}$

,qF $\hat{n}$vdgJ fljjad gugGfF nrqFjjhd› ntsd Nehffa jiraYss XuyF ntflh. σ< 0 vdy› kdGykhdJ gugGfF nrqFjjhf› cs Nehffa jiray ,UfFk.

fljjad Gwggugg Yk clGwjjYk eiy kddOjjk xNu kjgG nfhzbUfFk. fljjad Gwggugg y gugg wF ,izahd jiray kdGyjjd $W ,UffhJ vdgjhy gugg y kdJfsfis efhjJtjwF Ntiy nraaj Njitayiy. ,jwF gugg Yss midjJ Gssfs Yk kddOjjk rkkhf ,Uff NtzLk myyJ gugg Yss› VNjDk ,U GssfSfF ,ilNaAss kddOjj NtWghL Roahf ,Uff NtzLk. fljjad clGwk kdGyk Roahjyhy› fljjad Gwggugg y css kddOjjKk clGwk css kddOjjKk rkkhf ,Uff NtzLk. vdNt› eiykd rkeiyay xU fljj vgNghJk rkkddOjjjjy cssJ.

eiykd; jLgGiw (Electrostatic shielding):

fh] tjiag gadgLjj kddD}llk ngww Nfhsff $lbd clGwjjy kdGyk Ronadgij eWtNdhk. csslww kwWk jzk Nfhsf fljjfs ,itauzbd clGwqfsYk kdGyk RonadgijAk fzNlhk. ,J xU tagGlLk gzghfTk Kffakhdnthu tisitj jUtjhfTk cssJ.

fljj xdwd clGwKss FoTg gFj (Cavity) xdiwf fUJNthk. fljjad Gwggugg Yss kdJfsfs vJthf ,UejhYk fljjfF ntsNa VwgLk kdday khWghLfs vJthaDk mfFoTg gFjad clGwk kdGyk RoahfNt ,UfFk. GwjNj VwgLk kdday khWghLfsyUeJ Elgkhd kd fUt xdiwg ghJfhff NtzLnkdy ,jjifa FoTg gFjfFs itff NtzLk. ,ijNa eiykd jLgGiw vdgh.

,ttisit nraJ fhll ghuNl $zL (Faraday cage) vdnwhU mikgG cssJ. cNyhfj jzLfshy nraaggll ,f$zL fhllgglLssJ.

ntsNa cUthffggLk nrawif kddyhy jhffggLk NghJk $zbwFs css kdjh vej ghjgGfFk csshtjyiy.

kddy› ,bAld $ba kioad NghJ jwej ntsaNyh myyJ kujjdbaNyh ewgij tl NgUejwFs ,UggJ ghJfhgghdJ. NgUejd cNyhfg gugG eiykd jLgGiwahfr nraygLfwJ. Vnddy mjd clGwjjy kdGy kjgG Ro. kddyd NghJ fljjad GwggugG toNa kdJfsfs jiufFg ghatjhy NgUejDs ,UggtUfF vttj ghjgGk ,UffhJ.

eiykd; J}z;ly;

jFej nghUs xdwdhy ,dndhdiw cuRtjhy kdNdwwk nraa KbAk vdgij ,tthwhf kddD}llk ngww nghUis ,dndhU fljjahy njhLkNghJ› kdJfsfs fljjia milfdwd. Mdhy njhLjy ,dwNa fljjnahdiw kdNdwwk ngwr

nraa KbAkh? KbAk. njhLjy ,dwNa xU nghUis kdNdwwk ngwr nraAk efoT eiykd J}zly vdggLk.

1. kdfljjhj jhqf xdwd kJ itffgglLss kdD}llkww (kd eLeiyahd) Nfhs tbtf fljjg nghUs xdiwf fUJNthk. vjh kdD}llk ngww jzL xdW Nfhsjjd mUfy› mijj njhlhjthW› nfhzL tuggLfwJ

jzbYss vjhkdJfs fljjaYss vyfluhdfis vjhggffjij Nehff tulLfwJ. ,jd tisthf› kdD}llk ngww jzL ,UfFk gffjjy Neh kdJfsfSk mjwF vjhggffjjy vjh kdJfsfSk J}zlggLfdwd.

1. kdD}llk ngww jzbidf nfhzL tUKd› fljjad (Nfhsjjd gugG KOtJk flLwh vyfluhdfs ruhfg gutaUejd. NkYk mjd efu kdD}llk Roahf ,UejJ. Mdhy› jzbid fljjadUfy nfhzL nrdwTld vyfluhdfs jzbwF Nraikg gffjjYk Neh kdJfsfs mzikg gffjjYkhf mikeJ› kdJfsfsd guty ruwwjhfwJ. ,Uggdk› efu kdD}llk Rona.

2. ,gNghJ Nfhsf fljjia xU kdfljJf fkgad %yk jiufF ,izgG nfhLffggLfwJ. ,jwF jiuaizgG (Grounding) vdW ngah. vttsT vyfluhdfis NtzLkhdhYk jiuahy (Gtahy) VwWfnfhss KbAkhjyhy Nfhsff fljjaYss vyfluhdfs jiuaizggdhy jiufFs nrdW tLfdwd. Mdhy Nfhsjjy css Nehkdjfsfs jzbYss vjh kdJfsfsd fthrr tirfF clglLssjhy› ,ej Nehkd Jfsfs jiufF gha ,ayhJ.

3. ,gNghJ jiuaizgGf fkgaid vLjJ tl› Nfhsjjy Neh kdJfsfs kdD}llk ngww jzbwF mUfNyNa cssd.

4. kdD}llk ngww jzbid ,gNghJ fljjalkUeJ mgGwggLjj tlTk. mtthW mjid effaTld Neh kdJfsfs fljjad gugg y ruhfg guTfdwd. ,jjifa nrayKiwad %ykhf kdeLeiyj jdik nfhzl xU Nfhs tbtf fljj Neh kdD}llk ngwwjhf khWfwJ. (xU Fwggll tbtk vdwyhky) ruww tbtk nfhzl fljjfF› ,rnrayKiway ,ilayikej gbfSk KbTk xdwhf ,Uggdk filr gb NtWglL ,UfFk. mjhtJ› Neh kdJfsd guty ruhf ,uhJ. ,J Vd? ,jwfhd fhuzk gFj tthjffgglLssJ.

	kd;D}l;l mww vwnghUs;	+q kd;D}l;lk; ngwwJ
gwfFk Neuk T	$\frac{2v_0 \sin q}{g}$	$\frac{2v_0 \sin q}{\left(g + \frac{qE}{m}\right)}$
ngUk cauk h_{max}	$\frac{v_0^2 \sin^2 q}{g}$	$\frac{v_0^2 \sin^2 q}{2\left(g + \frac{qE}{m}\right)}$
(filjjs) neLffk R	$\frac{v_0^2 \sin 2q}{g}$	$\frac{v_0^2 \sin 2q}{\left(g + \frac{qE}{m}\right)}$

gwfFk Neuk› ngUk cauk› neLffk Mf‌a ,k%dWNk nghUs‌d KLffjj‌wF vj‌hjjft‌y cssij ftd‌ffTk NkYk› $g + \frac{qE}{m} > g$ Mifahy T, h_{max}, R ,k%dW msTfSNk k‌dD}llkww e‌iya‌y css msTfis t‌lf Fiwej kj‌gigg ngww‌UfFk. k‌dD}llkhdJ –q vd‌y› $g - \frac{qE}{m} < g$. Mifahy ,k%dWNk mj‌f kj‌gG ngww‌UfFk. ,Ugg‌Dk nghUs‌d ghij ,ddKk gutisakhfNt cssJ.

k‌d;fhgGg nghUs;fs; my;yJ k‌d;flj;jhg nghUs;fs;

k‌dfhgg nghUs vdgJ k‌dNdhlljijf fljjhj xU nghUs. mj‌y flLwh vyfluhdfs‌d vzz‌fif FiwT. k‌dfhgGg nghUs‌Yss vyfluhdfs mjd mZffshy flLzL cssd. k‌dfhgGfSfF r‌y vLjJffhlLfs: vNghidl› fzzhb› ikffh Nghdwit Gw k‌dGyjj‌y itffggLk NghJ (k‌dfhgGfs‌y css) vyfluhdfshy flLwh ,ayGld ,aqf KbahJ. Mdhy Fwggll j‌ira‌y mit xOqfikffg gLf‌dwd. k‌dfhgGfs k‌dKidTss (polar) %yf$Wfs myyJ k‌d Kidtww %yf$Wfshy Mdit.

k‌d;Kidtww %yf;$Wfs; (Non polar molecules):

Neh k‌dJfsfs‌d k‌ddD}ll ikaKk vj‌h k‌dJfsfs‌d k‌ddD}ll ikaKk xNu Gss‌a‌y nghUej‌ mikf‌dw %yf$W k‌d Kidtww %yf$W vdggLk. ,J e‌iyjj ,UKid j‌UgGjj‌widg ngww‌Uggj‌yiy. vLjJffhlLfs: i`bu[d (H_2)› Mfr‌[d (O_2)› fhhgd ilahfirL (CO_2) css‌llit.

,gnghUsfis Gw k‌dGyjj‌y itjjhy› Neh k‌dJfsfs‌d k‌ddD}ll ikaKk vj‌h k‌dJfsfs‌d k‌ddD}ll ikaKk r‌wa ,ilnts‌ nfhzL gh‌ffggLf‌dwd. ,jdhy Gw k‌dGyjj‌d j‌ira‌y ,UKid j‌UgGjj‌wd J}zlggLf‌wJ. ,gNghJ› Gw k‌dGyjjhy k‌dfhgG nghUs k‌dKidthffk nraagglLssJ (Electrically polarised) vdW $wyhk.

k‌d;KidTs;s %yf;$Wfs; (Polar molecules):

Gw k‌dGyk nraygLhj e‌iya‌Yk Neh kwWk vj‌h k‌dJfsfs‌d k‌ddD}ll ikaqfs gh‌ffgglLss %yf$Wfs k‌dKidTss %yf$Wfs vdggLk. ,it e‌iyjj ,UKid j‌UgGjj‌widg ngwWssd. ntgg ,affjj‌d t‌isthy nghUs‌y css xtnthU ,UKid j‌UgGjj‌wDk› xOqfwW nttNtW j‌iria Nehff‌ mikf‌dwd. vdNt Gwk‌dGyk ,yyhj e‌iya‌y e‌fu ,UKid j‌UgGjj‌wd Ro‌ahFk. Kidtss %yf$WfSfF vLjJffhlLfs H_2O, N_2O, HCl, NH_3.

Mdhy Gw k‌dGyk nraygLk NghJ› Kidtss %yf$w‌Yss ,UKidfs k‌dGyjj‌d j‌ira‌y xOqfikf‌dwd. vdNt› ,U e‌fu ,UKid j‌UgGjj‌wd mjDs J}zlggLf‌wJ. ,gNghJ› Gw k‌dGyjjhy k‌dfhgG nghUsk‌dKidthffk nraagglLssJ vdyhk.

k‌d;Kidthf;fk; (Electric Polarization):

Gw k‌dGyk nraygLk NghJ xU k‌dfhgGg nghUs‌y ,UKid j‌UgGjj‌wd J}zlggLf‌wJ. k‌dfhgGg nghUs‌y XuyF gUkd‌y (J}zlggLk) nkhjj ,UKid j‌UgGjj‌wid Kidthffk $\left(\vec{P}\right)$ vdgh. ngUkghyhd (Neh‌ay j‌irrrh jdik nfhzl –linear isotropic) k‌dfhgGfs‌y› Kidthffkhd J Gw k‌dGyjj‌d ty‌ikfF Nehjjft‌y ,UfFk. ,ijNa›

$$\vec{P} = c_e \vec{E}_{ext}$$

,qF c_e vdw khwpy; kpd VwGjjpwd (Susceptibility) vdggLk. ,J xtnthU kpdfhgGg nghUspwFk nttNtW kjpgigAilajhf ,UfFk.

kpd;fhggpd; csNs kpdGyk; J}z;lggLjy;:

fljjpnahdiwg Gw kpdGyjjpy itfFkNghJ› mjpYss kpdJfsfs xUqfikffgglL› mjdhy cUthFk mf kpdGykhdJ Gw kpdGyjij rkd nraAk. Mdhy kpdfhgigg nghUjjtiu› mjpy flLwh vyfluhdfs ,yyhjjhy› Gw kpdGykhdJ mjpYss kpdJfsfis xUqfikffr nrajhYk mjdhy cUthFk mf kpdGyk Gw kpdGyjij tplf Fiwthf ,UfFk. vdNt› kpdfhggpd clGwk epfu kpdGyk Ropahtjpyiy; NkYk Gw kpdGyjjpd jpirapNyNa epfu kpdGyk ,UffpwJ. Mdhy mjd vzkjpgG Gw kpdGyjijtplf FiwthfNt ,UfFk. vLjJffhllhf› (kpdNjff xdwpd) vjpnujph kpdD}llk ngww ,U jlLfSfF ,ilNa xU nrttf tbt kpdfhgGg ghsk itffggLfpwJ. jlLfSfF ,ilNa epyTk ruhd kpdGyk kpdfhggpwF xU Gw kpdGykhf $\left(\vec{E}_{ext}\right)$ nraygIL mjid Kidthffk nrafpwJ. mjd xU gffjjpy Neh kpdJfsfSk kwnwhU gffk vjph kpdJfsfSk J}zlggLfpdwd. Mdhy kpdfhggpd clGwjjpNyh xU rpW gUkdpy $l epfu kpdD}llk Ropahf ,Uffpdw J. MfNt Gw kpdGyjjpy itffggLss xU kpdfhgghdJ kpdD}ll gugglhjjp + s_b kwWk - s_b nfhzl› vjpnujph kpdD}llk ngww ,U jlLfSfF xgghFk. ,kkpdJfsfs flLzl kpdJfsfs (Bound Charges) vdggLk. ,it fljjpapYss flLwh vyfluhdfisg Nghy ,it jilaww ,affjijg ngw KbahJ.

vLjJffhllhf› cuhatpdhy kpdD}llk ngww gY}d xdW Rtwwpy xlbf nfhsfpwJ. vjph kpdD}llk ngww gY}id RtwwpdUfpy nfhzL tUkNghJ› mJ Rtwwpy Ntwpd kpdJfsfisj J}zLtjhy Kidthffk VwgLfpwJ. ,jdhNyNa RtwWld gY}d xlbf nfhsfpwJ.

kpd;fhgG typik (Dielectric Strength):

kpdfhggpwF msptffggLk Gw kpdGyk mjpf typik thaejjhf ,Uejhy mJ mZffspy css vyfluhd fllikgig cilJ flLzl kpdJfsfis flLwh kpdJfsfshfFfpdwJ. ,eepiyapy kpdfhgGg nghUs kpdNdhlljijf fljj Mukgpffpdw J. ,ijNa kpdfhgG KwpT (dielectric break down) vdgh. ,kKwpT VwgLk Kd kpdfhgG xdW jhqff$ba ngUk kpdGyk kpdfhgG typik vdggLk. vLjJffhllhf› fhwwpd kpdfhgG typik 3×10^6 V m^{-1}. ,jwF mjpfkhd kpdGyjij nraygLjjpdhy› mjpy nghwp cUthFk. rpy kpdfhgGfspd kpdfhgG typikfs glbaypgglLssd.

kpd;fhgG typik:

nghUs;	kpd;fhgG typik (Vm^{-1})
ikffh	100×10^6
nlgyhd	60×10^6
fhfpjk	16×10^6
iguf] fz zhb	14×10^6
fhwW	3×10^6

kpdNjf;fpfs; kwWk; kpdNjf;Fj;jpwd;

kdNjf;fpfs; (Capacitors):

kdJfsfs kwWk kddhwwiy Nrkff cjTk fUtNa kdNjffp mJ rwa ,ilntspapy ghjJ itffgglL ,U kdfljJg nghUsfshy (nghJthf jlLfs myyJ jfLfs) MdJ. gy vyfluhdpa RwWfspYk. mwtpay njhopElgj Jiwfs gytwwpYk kdNjffp gutyhf gadgLjjggLfpwJ.

Xh vspa kdNjffpapy ,U ,izahd cNyhfj jlLfs rwpa ,ilntspapy ghffgglL cssij fhzyhk. kdNjffpia V kddOjj NtWghL nfhzl kdfyDld ,izjj gpdG kdfydpypUeJ (kdNjffpapd) xU jlbwFk ,dndhU jlbypUeJ kdfyDfFkhf vyfluhdfs ,lkngahtjhy xU jlL – Q vjph kdD}llKk ,dndhdW +Q Neh kdD}llKk ngWfpdwd. jlLfSffpilNaahd kddOjj NtWghL kdfydpd Kid kddOjj NtWghlLfFr rkkhFk. kdfydpd kddOjj NtWghL mjpfhpffgglhy jlLfspy Nrkpffggk kdJfsfspd msTK mjpfhpfFk. nghJthf kdNjffpapy Nrkpffggll kdJfsfspd kdD}ll kjpgG mjd jlLfSffpilNa css kddOjj NtWghlLfF Nehjjftpy ,UfFk.

Q ¥ V, myyJ Q = CV,

,qF C vdw jfT khwpy. ,J kdNjfFjjpwd (Capacitance) vdggLk. kdNjffpapd kdNjfFjjpwd C vdgJ mjd VNjDk xU kdfljJ jlby css kdJfsfspd kdD}ll kjpggpwFk fljjfSfF (jlLfSfF) ,ilNa epyTk kddOjj NtWghlbwFk ,ilNaTss tpfpjk vd tiuaWffggLfpwJ.

$$C = \frac{Q}{V}$$

kdNjfFjpwdpd SI myF $Y}k / Nthyl ($CV^{-1}$) myyJ ikfNfy ghuNlapd epidthf ghul (F) vdWk Fwpffggfpwf. ghul vdgJ kdNjfFj jpwdpd kfgnghpa Xh myF. eilKiwapy ikfNuhghul ($1\mu F = 10^{-6}F$) Kjy igfNfhghul ($1pF = 10^{-12}F$) tiuapyhd kjpgGfSld kdNjffpfs fpilffpdwd.

kdNjffp myyJ Mfpa FwpaLfshy Fwpggplggfpwf. kdNjffpapd ,U jfLfspy Nrkpffggk kdJfsfspd nkhjj kdD}llk Ro (Q – Q = 0) vdgijf ftdpffTk. kdNjffp xdwpy kdJfsfs Nrkpjf itffggLdwd vd ehk nrhyYk NghJ mjd xU jlby Nrkpffggk kdJfsfspd kdD}ll msitNa Fwpggpfpwhk.

,diwa fhyflljjpy kdNjffpfs gytpj tbtqfspYk (cUis tlL) tiffspYk (lhzlyk gqfhd kdgF kdNjffpfs) fpilffpdwd.

,izjjlL kdNjffpapd kdNjfFjjpwd:

FWfFntlLg guggsT A kwWk d ,iljnjhiytpdhy ghpjJ itffgglLss ,U ,izjjlLfisf nfhzl kdNjffpiaf fUJNthk.

,U Kbtpyh ,izj jlLfSffpilapy kdGyk ruhfTk $E = \frac{s}{e_o}$ kjpgG nfhzLk ,UfFk. ,qF *s* vdgJ jlLfspd kdD}llg guggljjp $s = \frac{Q}{A}$ jlLfspd guggsitf fhlbYk ,iljnjhiyT d kfTk rwajhf ,Uggpd ($d^2 << A$), tukgpwFlgll msT nfhzl (finite sized) ,izjjlL kdNjffpfFk $l NkNy $wggll rkdghL nghUeJk.

vdNt jlLfSffpilNaahd kdGyk

$$E = \frac{Q}{Ae_0}$$

kdGyk ruhf ,Uggjhy› jlLfSfF ,ilNaahd kddOjj NtWghL

$$V = Ed = \frac{Qd}{Ae_0}$$

vdNt kdNjffiad kdNjfFjjwd

$$C = \frac{Q}{V} = \frac{Q}{\frac{Qd}{Ae_0}} = \frac{e_0 A}{d}$$

kdNjfFjjwd jlbd FWfFntlLg guggstwF Nehjjftiyk ,U jlLfSffilNaAss njhiytwF vjhjjftiyk cssJ vdgij mwayhk. gdtUk gFgghatid %yKk ,ij mwayhk.

1. kdNjffij jlLfsid guggsit mjfhjjhy mNj kddOjj NtWghlby ,dDk mjfsT kdJfsfisg gutr nraa ,aYk. vdNt› kdNjfFjjwDk mjfkhFk.

2. jlLfSfF ,ilNa css njhiyT d lf FiwfFkNghJ E khwy Mjyhy› mtwWfF ,ilNaahd kddOjj NtWghLk (V) FiwAk (V= Ed). ,gNghJ kdfydid ,UKidfSfF ,ilNaahd kddOjj NtWghL mjfkhf ,Uggjhy› Kidfsid kddOjj NtWghLk jlLfSfF ,ilNaahd kddOjj NtWghLk rkkhFk tiu kdfyjjyUeJ jlLfSfF kdJfsfs ghAk. khwhf› jlbilj njhiyitf $lLkNghJ› kdNjffiad kddOjj NtWghLk $Ltjhy ,gNghJ mJ kdfydid kddOjjjij tl mjfkhf ,UfFk. ,U kddOjjqfSk rkkhFk tiu kdNjffij jlLfsyUeJ kdfyDfF kdJfsfs ghAk.

kdNjffiay; NrkffggLk; Mwwy;

kdNjffiahdJ kdJfsfis klLkyy› kddhwwiyAk Nrkffk xU fUtiahFk. kdNjffi xdW kdfyDld ,izffggLk NghJ –Q kddD}ll msTila vyfluhdfs mjd xU jlbyUeJ ,dndhdWfF ,lkngahfidwd. ,ej kdJfs ,lngahTfF Njitggk Ntiyia kdfyd nrafwJ. nraaggll ,tNtiyNa kdNjffiay eiy kddOjj Mwwyhfr Nrkij itffggLfwJ.

V kddOjj NtWghlby dQ msT (infinitesimal) kddD}llk nfhzl kdJfsfis efhjj nraaggLk Ntiy

$$dW = V\,dQ$$

,qF $V = \frac{Q}{C}$ vdNt

kdNjffiia kdNdwwk (charge) nraaj Njitggk nkhjj Ntiy

$$W = \int_0^Q \frac{Q}{C} dQ = \frac{Q^2}{2C}$$

,ej Ntiy eiy kddOjj Mwwyhf (U_E) kdNjffiay NrkffggLfwJ.

$$U_E = \frac{Q^2}{2C} = \frac{1}{2}CV^2 \quad (\because Q = CV)$$

,tthW Nrkffggll MwwyhdJ kdNjfFjjwDfFk jlLfSfF ,ilNaahd kddOjj NtWghlbd ,UkbfFk Nehjjftiy ,Uffidwj. Nrkffggk ,tthwwy

vqNf cssJ? ,ij mwpa rkdghL gpdtUkhW khwwp vOjyhk. ,qF C = $\frac{e_o A}{d}; V = Ed$

$$U_E = \frac{1}{2}\left(\frac{e_0 A}{d}\right)(Ed)^2 = \frac{1}{2}e_o(Ad)E^2$$

,qF Ad = kpdNjffpapd jlLfSffpilNa css gFjpapd gUkd. ,ej ,ilntspggFjpapd xuyF gUkdpy Nrkpffgg lLss Mwwiy› epiy kpddOjj Mwwy mlhjjp (u_E) vd tiuaWffyhk.

vdNt $u_E = \frac{U_E}{V}$

rkdghL lg gpujpapl

$$u_E = \frac{1}{2}e_o E^2$$

,jypUeJ› kpdNjffpapd jlLfSffpilNa css ,ilntspapy epyTk kpdGyjjpyjhd Mwwy Nrkpffgg LfpwJ vdgij mwpeJ nfhssyhk. kpdNjffpia kpddpwffk (discharge) nraAkNghJ Mwwy jpUkgg ngwggLfpwJ.
Mwwy mlhjjpahdJ kpdGyjijr rhheJ klLNk cssJ vdgijAk jlLfspd msitg nghWjJ mJ miktJ ,yiy vdgijAk ftdpffTk. NkYk› rkdghL vttif kpdJfs epiyaikgGfFk nghUejf$ba xdwhFk.

kpdNjfpfspd gadghLfs;
gyNtW vyfluhdpa RwWfspYk kpdNjffpfs gadgLjjggLfpdwd. mtwWs rpytwiw ,qF fhzNghk.

1. ehk midtUk mwpej xdWjhd xspgglf fUtp (difital camera), ehk Gifgglk vLfFk NghJ mjpypUeJ njwpgnghspp (flash) ntspggLtjwF njwpgG kpdNjffp vdggLk xUtif kpdNjffpapypUeJ ntsptplggLk MwwNy fhuzkhFk.

2. ,ja epWjjk (Cardiac arrest) VwgLk NghJ› ,ja cjwy effp (Heart difibrillator) vdw xU fUtpiag gadgLjjp jpBnud mjpfstpyhd kpddhwwiy Nehahspapd neQRg gFjpapy nrYjJtjd %yk ,jajJbgig ,ayGfFf nfhzL tUthhfs. ,ffUtpapy 2000V mstpyhd mjpf kpddOjjjjpy kpdNdwwk nraaggll 175 *mF* kpdNjffp gadgLjjggLfpwJ.

3. jhdpaqfp vejpuqfspd› vhpnghUs vhpAilLk mikgGfspy› jgnghwp cUthtij jtphff kpdNjffpfs gadgLfpdwd.

4. kpd toqfpfspy (Power supplies) kpdjpwd Vww ,wffjijf FiwggjwFk kpdjpwd mDgglby mjd gaDW jpwid mjpfhpffr nraaTk kpdNjffpfs gadgLfpdwd.
,UggpDk› rpy FiwghLfSk kpdNjffpfSfF cssd. kpdfyidNah kpdtoqfpiaNah mizjj gpdGk kpdNjffpapy Njffp itffggll kpdJfsfSk kpddhwwYk rpwpJ Neuk ,UfFk. vLjJffhllhf› njhiyffhlrpg nglbia mizjj cld rwW Neuk tiu mjd gpdgffjijj njhlhky ,Ujjy mtrpak.

kpdNjfpfspy; kpdfhgGfspd tpisT:

,Jtiu ehk ghhjj tpsffqfspy› xU kpdNjffpapd ,izjjlLfSfF ,ilNaAss ntspggFjp ntwwplkhf cssjhfNth myyJ fhwwhy epuggljhfNth

vLjJf nfhzNlhk. kdfhgGg nghUsfshd ikfffh› fzzhb myyJ fhfjk Nghdwtwiw jlLfSfF ,ilNa GFjjdhy kdNjffad kdNjfFjjwd khwwk milAk.

jlLfSffilNa kdfhggid› ,U NtW eiyfsy GFjjyhk.
1. kdfyDld ,izgG Jzbffgglleiyay kdNjff cssNghJ
2. kdfyDld ,izffgglleiyay kdNjff cssNghJ

kdfyDld ,izgG Jzbffgglleiyay kdNjff

A FWfF ntlLg guggsTila ,U ,izjjlLfs d ,ilntsay gphpjJ itffgglLss kdNjff xdiwf fUJNthk. $V_o$kddOjjKila kdfydhy kdNjffahdJ $Q_o$kdD}llk nfhzl kdJfsfis Nrkffk mstwF kdNdwwk nraaggLfwJ. ,eeiyay kdNjffad kdNjfFjjwd

$$C_o = \frac{Q_o}{V_o}$$

kdfyDldhd ,izgigj Jzbjj gdG› jlLfSfF ,ilNa kdfhgG EioffggLfwJ.

kdfhgig Eiojj cld jlLfSffilNaahd kdGyk FiwAk. Matd mbggilay› khwwkilej kdGyjij (E) gdtUk rkdghlbdhy mwayhk.

$$E = \frac{E_o}{e_r}$$

,qF $E_o$vdgJ kdfhgG ,yyhj eiyay kdNjffffF ,ilay css kdGyk kwWk ε_r vdgJ kdfhggd rhhG tLjwd (relative permittivity) myyJ kdfhgG khwy vdggLk. ,qF $\varepsilon_r > 1$ vdgjhy $E < E_o$MFk.

,jd tisthf› jlLfSffilNa css kddOjj NtWghLk (V = Ed) FiwAk. mNj rkak› kdfyDld ,izgG ,yyhjjhy Njffggll kdJfsfs vqFk nryyhJ. mjdhy kdD}ll kjgG Qok khwhJ ,UfFk.
vdNt Gja kddOjj NtWghL›

$$V = Ed = \frac{E_o}{e_r} d = \frac{V_o}{e_r}$$

kddOjj NtWghlbwF vjhjftyy kdNjfFjjwd cssjhy›V Fiwa C mjfhffFk.

kdfhgG css eiyay kdNjfFjjwd

$$C = \frac{Q_o}{V} = e_r \frac{Q_o}{V_o} = e_r C_o$$

$\varepsilon_r > 1$ Mjyhy $C > C_o$. vdNt $\varepsilon_r$khwyAila kdfhgigg GFjja gdG kdNjfFjjwd mjfhffdwJ.

kdfhgigg GFjja gdG kdNjfFjjwd mjfhffdwJ.
rkdghL –d gb

$$C = \frac{e_r e_o A}{d} = \frac{eA}{d}$$

$\varepsilon = \varepsilon r, \varepsilon_0$,qF ε vdgJ kdfhgG Clfjjd tLjwd vdggLk.

kdfhgig EiofFk Kd kdNjffay Nrkffggll Mwwy

$$Uo = \frac{1}{2}\frac{Q_0^2}{C_o}$$

kdfhgG Eioffggll gdG› kdD}llk $Q_o$khwhkYk kdNjfFjjwd C mjfhjJk fhzggLtjhy Nrkffggll Mwwyd msT FiwAk.

$$U = \frac{1}{2}\frac{Q_0^2}{C} = \frac{1}{2}\frac{Q_0^2}{e_r C_0} = \frac{U_0}{e_r}$$

$\varepsilon_r > 1$ Mjyhy $U < U_o$ kdfhgigg GFjJkNghJ› mij kdNjff csNs ,Offwj. ,jwfhf rwJ Mwwy nrytlggLtjhNyNa kdNjffad Mwwy msT Fiwfdwj.

kd;fyDld; ,izf;fggl;l epiyay; kdNjf;f

kddOjjk $V_o$cila kdfyDld kdNjffahdJ ,izffggll epiyaNyNa kdfhgig Eiojjhy vdd Nehfwj vdgij ,gNghJ ghhgNghk.

jlLfSfF ,ilNaahd kddOjj NtWghL $V_o$khwhky ,UfFk. Mdhy ,eepiyay kdfhgigg GFjjdhy kdNjffaay Nrkffggk kdJfsfsd msT $\varepsilon_r$klqfhf caUk vdgij MaTfsd %yk (,ij Kjyy nraJ fhlbath ghuNl) mwfNwhk.

$$Q = \varepsilon_r Q_o$$

kdJfsfsd msT mjfhggjhy› kdNjfFjjwDk mjfhffk. Gja kdNjfFjjwd

$$C = \frac{Q}{V_o} = e_r \frac{Q_o}{V_o} = e_r C_o$$

vdDk› kdfyDld ,izffggll epiyaYss kdNjffad kdNjfFjjwd mjfhggjwfhd fhuzKk kdfyDld ,izgG Jzbffggll epiyaYss kdNjffad kdNjfFjjwd mjfhggjwfhd fhuzKk nttntW.

$$C_o = \frac{e_o A}{d}$$

kwWk $C = \frac{eA}{d}$

kdfhgigg GFjJtjwF Kd Nrkffggll Mwwy

$$U_o = \frac{1}{2} C_o V_o^2$$

,qF $U_o = \frac{1}{2}\frac{Q_o^2}{C_o}$ vdw rkdghlil ehk gadgLjjhjijf ftdffTk. Vnddy› kdJfsfsd msTk kdNjfFjjwDk khWfdw ,eNehtly V_o klLNk khwhky cssJ.

kdfhgig Eiojjgdg› kdNjfFjjwd mjfhffwJ. ,jdhy Nrkffggll MwwYk mjfhffwJ.

$$U = \frac{1}{2} C V_0^2 = \frac{1}{2} e_r C_0 V_0^2 = e_r U_0$$

$\varepsilon_r > 1$ Mjyhy $U > U_o$

kdNjffad kddOjj NtWghL $V_o$khwhky cssjhy jlLfSffilNa eyTk kdGyKk khwhky ,UfFk vdgijf ftdffTk.

Mwwy mlhjj $u = \frac{1}{2} e E_0^2$

,qF εvdgJ kdfhgG Clfjjd tLjwd MFk. ,kKbTfs fhllgglLssd.

t.vz;	kd;fhgG GFj;jggLk; NghJ	kd;D}l;lk; Q	kd;dOj;j NtWghL V	kd;Gyk; E	kd;Njf;Fj; jwd; C	Mw;wy; U
1.	kdfyd ,izgG Jzbffgg lL ,Uejhy	khw;y	FiwAk	FiwAk	caUk	FiwAk
2.	kdfyd ,izffgg lL ,Uejhy	caUk	khw;y	khw;y	caUk	caUk

kd;Njf;fs; njhlh;izgg;Yk; gf;f ,izgg;Yk; njhlh;izgg;y; kd;Njf;fs;

kddOjj NtWghL V nfhzl kdfyDld %dW kdNjff;fs njhlh;izgg;y cssd mtww;d kdNjff;jjwdfs C_1, C_2kwWk C_3 kdfyd;d kd ,izgG nfhLffgg lTld C_3 kdNjff;a;d tyJgffj jlil Nehff; –Q kddD}ll msTila vyfluhdfs vjhkdtha;y;UeJ ,lkngahf;dwd. ,kkddD}llk mNjasT vyfluhdfis (-Q kddD}llk) C_3 kdNjff;a;d ,lJgffj jlby;UeJ C_2 d tyJgffj jlil Nehff; t;ulLf;dwJ. ,J e;iyk;d J}zly;dhy e;fof;wJ. ,Nj Nghy C_2 ,d ,lJ gffj jlL›-Q kddD}ll msTss vyfluhdfis C_1 d tyJgffj jlil Nehff; t;ulLf;dwJ. e;iyk;d J}zly;d t;isthy C_1 d ,lJgffj jlby +Q kddD}llk cUthf;wJ. mNj rkak C_1 d ,lJgffj jlby;UeJ –Q msTss vyfluhdfs kdfyd;d Nehk;dthia Nehff; ,lkngahf;dwd.

,ee;foTfshy xtnthU kdNjff;a;Yk; rk msT kddD}llk Q nfhzl kdJfsfs Nrk;ffggLf;wJ. kdNjff;fs;d kdNjfFjjwd nttNtwhf ,Uggjhy mit xtnthdw;d FWfNf e;yTk kddOjj NtWghLk nttNtwhf ,UfFk. mit KiwNa V_1, V_2kwWk V_3MFk.

kdNjff;fs;d FWfNf fhzggLk nkhjj kddOjj NtWghL kdfyd;d kddOjj NtWghlLfFr rkkhf ,Uff Ntz Lk.

$$V = V_1 + V_2 + V_3$$

Q = CV Mjyhy $V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$

$$= Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

njhlh;izgg;Yss %dW kdNjff;fSk xU jd;jj kdNjff;ia cUthfFtjhff nfhzlhy

$$V = \frac{Q}{C_s} \text{ rkdghL g;uj;a;l›}$$

$$\frac{Q}{C_s} = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

xU jd;jj kdNjff;ia cUthfFtjhff nfhzlhy

$$V = \frac{Q}{C_s}$$ rkdghL gujail›

vdNt› kidNjffifs njhlhiz ggiy cssNghJ njhFgad kidNjfFjjiwd C_s d jiyfo kjiggh dJ xtnthU kidNjfFjjiwdid jiyfo kjigGfsid $LjYfFr rkkhFk. njhFgad kidNjfFj jiwdid kjigG C_s MdJ njhlhiz ggiYss kiff Fiwej kidNjfFjjiwid til vgNghJk Fiwthf Nt ,UfFk.

gf;f ,iz ggiy; kidNjf;fifs;

kiddOjj NtWghL V nfhzl kidfyDld %dW kidNjffifs gff ,iz ggiy cssd mtwwid kidNjfFjjiwdfs C_1, C_2 kwWk C_3kidNjffifsid xjj gffqfs kidfydid xNu NehKid kwWk vjhkidKidAld ,iz ffgglL ,Uggjhy› xtnthU kidNjffifFf FWfNf NjhdWk kiddOjj NtWghL rkkhfTk mJ kidfydid kiddOjj NtWghlLfFr rkkhfTk ,UfFk. xtnthU kidNjffiaid kidNjfFjjiwDk nttNtwhf ,Uggjhy mtwwiy NjffggLk kidJfsfsid msTfSk nttNtwhfNt ,UfFk. kidNjffifsiy Nrkiffggk kidJfs msTfs KiwNa Q_1,Q_2 kwWk Q_3 vdf. nkhjj kiddD}ll khwh tijaid gb ,k%dW kidJfsfsid kiddD}llqfsid $LjyhdJ kidfydiyiUeJ ngwggll kidJfsfsid kiddD}llk Q fF rkk vdyhk.

kidJfsfsid kiddD}llk Q fF rkk vdyhk.

$Q = Q_1 + Q_2 + Q_3$

$Q = CV$ vdgjhy

$Q = C_1V + C_2V + C_3V$

,k%dW kidNjffifSk xU jdijj kidNjffiia cUthfFtjhff nfhzlhy mjiy NjffggLk kiddD}llk $Q = C_pV$ vdyhk.

rkdghL gujail›

$C_pV = C_1V + C_2V + C_3V$

$C_p = C_1 + C_2 + C_3$

kidNjffifs gff ,iz ggiy cssNghJ mtwwid njhFgad kidNjfFjjiwd Cp ahdJ jdijjdi kidNjffifs kidNjfFjjiwdfsid $LjYfFr rkk. njhFgad kidNjfFj jiwdid kjigG gff ,iz ggiYss mjifglr jdijj kidNjfFjjiwid til vgNghJk mjifkhfNt ,UfFk. gff ,iz ggiYss kidNjffi xtnthdwid guggsitAk $lLkNghJ fiilfFk njhFgad guggsT mjifkhf cssjhy mjd njhFgad kidNjfFjjiwDk mjifkhf cssJ.

kid;fl;jiaiy; kid;Jfs;fsid; gutYk; $H;Kidr; nrayghLk;

kid;fl;jiaiy; kid;Jfs;fsid; guty;

Muqfs KiwNa r_1, $r_2$nfhzl A, B vdw ,U kidfljJ Nfhsqfs xU nkyyia fljJ fkgaidhy xdNwhnlhdW ,iz ffgglLssd. NfhsqfSfF ,ilggll njhiyT mtwwid Muqfis til kifTk mjifk vd itffTk.

VNjDk xU Nfhsjjiwf Q msT kiddD}llk nfhzl kidJfsfs msiffggLkNghJ› ,U Nfhsqfsid kiddOjjKk rkkHFk tiu ,kkidJfsfs ,U Nfhsqfsiyk guTfidwJ. ,gNghJ Nfhsqfs ruhd kidJfs gutiyg ngWtjhy eiykid rkeiyia milfidwd. Nfhsk A d guggiy mikAk kiddD}llk $q_1$vdTk› Nfhsk B d guggiy mikAk kiddD}llk q_2 vdTk nfhzlhy›$Q = q_1 + q_2$fljjifsid GwgguggiNyNa kidJfsfs gutiAssd. NkYk fljjifsid clGwk vttij eifu kiddD}llKk ,UffhJ.

Nfhsk A d guggiy eiykiddOjjk

$$V_A = \frac{1}{4pe_o}\frac{q_1}{r_1}$$

Nfhsk B d gugg;y e;iyk;ddOjjk

$$V_B = \frac{1}{4pe_o}\frac{q_2}{r_2}$$

fljj;a;d gugG rk k;ddOjjj;y ,UfFk. NkYk Nfhsqfs fljJ fkg;a;y ,izffgglLssjhy mtww;d gugGfs ,izeJ xNu rk k;ddOjjg gugig cUthfFf;dwd.

$V_A = V_B$

myyJ $\frac{q_1}{r_1} = \frac{q_2}{r_2}$

Nfhsk A d k;dD}llg gugglhjj; s_1 vdTk Nfhsk B d k;dD}llg gugglhjj; s_2 vdTk itgNghk. ,j;y;UeJ›

$q_1 = 4pr_1^2 s_1$ kwWk

$q_2 = 4pr_2^2 s_2$ rkdghL y g;uj;a;l›

$\sigma_1 r_1 = \sigma_2 r_2$

,jd %yk

σr = khw;y;

mjhtJ› Nfhsjj;d k;dD}llg gugglhjj; σ mjd Mujj;wF vjhjjft;y cssJ. Muk Fiwthf ,Uejhy k;dD}llg gugglhjj; mj;fkhf ,UfFk myyJ Muk mj;fkhf ,Uejhy k;dD}llg gugglhjj; Fiwthf ,UfFk.

$hKidr; nrayghL (Action at points) **myyJ xs;tl;l k;d;dw;wf;fk;** (Corona Discharge):

VNjDk xU tbtKss k;dD}llk ngww fljj; xdiwf fUJNthk.

tisT Muk Fiwthf gFj;fs;y k;dD}llg gugglhjj; mj;fkhf ,UfFk vdgij ehk mw;Nthk. fljj;a;y tisTjjdik mj;fKss (Fiwej Muk) Kidfs;y k;dJfsfs mj;fkhff Ft;f;dwd.

,jdhy mkKidfF mUf;y k;dGyk k;Fej ty;ikAld cssJ. ,J mggFj;a;Yss fhwiw mad;ahffk nraf;wJ. ,gNghJ› $HKidfF mUf;Yss Neh k;dJfsfs t;ullggLf;dwd› vjh k;dJfsfs $hKidia Nehff; ftuggLf;dwd. ,jdhy fljj;a;d $hKidg gFj;a;Yss k;dJfsfs;d nkhjj k;dD}ll kj;gG Fiwf;wJ. ,ijNa $HKidr nrayghL myyJ xs;tll k;dd;wffk vdgh.

k;d;dy; jhq;f; myyJ k;d;dy; flj;jp:

caukhd flllqfis k;ddy ntlLfs;y;UeJ ghJfhff cjTk xU fUt; k;ddy fljj;. ,J flljj;d to;Na jiufFr nryYk xU ezl› jbjj jhk;uj jzbidf nfhzLssJ. mjd NkyKida;y $hKidAila Cr;fs nghUjjgglLssd.

jzbd fo KidahdJ mj;f Mojj;y Gijffgglss jhk;uj jlLld ,izffgglLssJ. vjh k;dD}llk ngww Nkfk flljj;d Nky nryYk NghJ› fljj;a;d $hKidfs;y Neh k;dD}llk J}zlggLf;wJ.
$h Kidfs;y J}zlggLk k;dJfsfs;d mlhjj; mj;fkhjyhy $hKidr nrayghL e;fof;wJ. Neh k;dD}llk ngwWss ,ej k;dJfsfs $HKidfSfF

mUfpYss fhwW %yf$Wfis madpahffk nrafpdwd. ,jd%yk cUthFk Neh kpdD}llqfs Nkfjjp Yss vjph kpdD}lljjpd xU gFjpia rkdnrafpwJ. $HKidfis Nehffp tpullggll vjph kpdJfsfs› jhkpuj jzbd topNa Gtpia Nehffp nryfpdwd. kpddy fljjp kpddiyj jLggjpyiy. khwhf jiuia Nehffp kpddiyj jpUgGtjd %yk flllqfisg ghJfhffpwJ.

thd; - b – fpuhg kpd;dpawwp:

1929 Mk Mzby uhghl thd b fpuhg vdgth gy kpyypad Nthyl (10^{7}V) mstpyhd kpf mjpf epiykpddOjj NtWghlil cUthfFk vejpuk xdiw tbtikjjhh. thd b fpuhg ,awwpad nrayghL epiykpd J}zly kwWk $hKidr nrayghL Mfpa jjJtqfspd mbggilapy mikfpwJ. kpdfhgG ngww jhqfpapd kJ xU nghpa csslww kpdfljJ Nfhsk nghUjjgglLssJ. Nfhsjjpd eLtpy B vdw fggpAk jhqfpapd mbggFjpfF mUfpy C vdw fggpAk nghUjjgglLssd. kpdfljjhg nghUsfshd glL myyJ ,ugguhy nraaggll glil xdW fggpfspd topNa nryfpwJ. fggp C kpdNkhllhh xdwpdhy njhlheJ ,affggLfpwJ. fggpfSfF mUNf $hKidfs nfhzl D kwWk E Mfpa ,U rgG tbtf fljjpfs ,izffgglLssd.

kpd toqfpapd %yk mstpyhd Neh kpddOjj NtWghlby rgG D itffggLfpwJ. rgG E MdJ Nfhsff $lbd clGwk ,izffgglLssJ.

rgG D fF mUfpYss cah kpdGyjjpdhy› rgG D fFk glilfFk ,ilapyhd gFjpapYss fhwW madpahffggLfpwJ. Neh kpdJfsfs glilia NehffpAk vjph kpdJfsfs rgG D l NehffpAk efhfpdwd. ,ej Neh kpdJfsfs glilapy xlbfnfhzL NkyNehffpr nryfpdwd. ,it rgG E l neUqFkNghJ epiykpd J}zlyhy mjpfstpyhd vjph kwWk Neh kpdJfsfs rggpd ,UKidfspYk cUthfpdwd. NkYk Neh kpdJfsfs rgG E ypUeJ tpullggll Nfhsjjpd GwggFjpia milfpdwd. Nfhsk fljjpgnghUshy Mdgbahy Neh kpdJfsfs Nfhsjjpd Gwgguggpy ruhfg guTfpdwd. mNj rkak› xsptll kpddpwffjjhy glilapYss Neh kpdJfsfis fhwwpYss vjph kpdJfsfs rkd nrafpdwd. gpddh glil fggpapd topNa fNo nryfpwJ.

glil fopwqFkNghJ› kpdD}llkww epiyia milfpwJ. fpNoAss rgig neUqfpaTld kzLk mjpf Neh kpdJfsfis glil VwfpwJ. NkNy nrdw gpd mJ kzLk Neh kpdJfsfis Nfhsjjpd GwgguggpwF mspffpdwJ. ,eepfoT njhlheJ VwgLfpwJ. Nfhsjjpd Gwgguggpy ngUk mstpy fplljjll 10^{7} V kpddOjj NtWghL cUthFk tiu ,J njhlhfpwJ. Nkwnfhzl Nfhsjjpy kpdJfsfs Vwfggl Kbahj epiyia vlbaTld› fhwwpd madpahffk fhuzkhf kpdJfsfs frpaj njhlqFfpdwd. cah mOjjjjpy thA epuggggll v/Ff fyjjpdhy Nfhsjij %Ltjd %yk› Nfhsjjpy pUeJ kpdJfsfspd frtpidf Fiwffyhk.

thd b fpuhg ,awwpad %yk ngwggLk cah kpddOjj NtWghL mZffUg gpsitapy gadgLk Neh madpfis (GNuhllhdfs kwWk bA‹lbuhdfs) KLfFtpffg gadgLfpwJ.

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12 ,awgpay;
myF 2

kpdNdhl;ltpay;

mwpKfk;

myF 1 ,y ehk kpdJfsfs Xatpy cssNghJ mtwwpd gzGfisg gwwp mwpeNjhk. Mdhy eilKiwapy nghUlfspy css kpdJfsfs Xatpyyhky vgNghJk ,aqfp nfhzNl ,UfFk. vLjJffhllhf jhkpuf fkgpapy css vyfluhdfs Xatpyyhky njhlheJ nttNtW jpirfspy ruww Kiwapy ,aqfp nfhzNl ,UfFk. vdNt ,affjjpYss kpdJfsfspd gzGfis gFjjhuhatJ ,dwpaikahjJ MFk. ,ej kpdJfsfspd ,affNk kpdNdhllk vdwioffggLfpwJ. kpdNdhlltpay vdgJ kpdJfsfspd ,affjijggwwpa gphpT MFk. ,ggphpthdJ myrhzNuh NthyNlh (1745-1827) tpd fzLgpbgghd kpdfyqfspy njhlqfpaJ. ,ej kpdfyqfNs› epiyahd kpdNdhlljij Kjd Kjypy toqfpd. etd cyfk kpdNdhlljjpd gadghlil ngUksT rhheJssJ. kpdNdhllkhdJ ,aejpuqfis ,afFjy› jfty njhlhG mikgGfs› kpddZtpay fUtpfs kwWk tlL cgNahf rhjdqfs Nghdwtwwpy gadgLfpdwJ.

,ej mytpy› ehk kpdNdhllk› kpdjil kwWk nghUlfspy ,it rhhej epfoTfisggwwp gapy csNshk.

kpdNdhl;lk;

gUgnghUs vdgJ mZffshy MdJ. xtnthU mZtpYk Nehkpdd}llk (Positive charge) ngww clfUTk (Nucleus) mjid Rwwp vjphkpdd}llk ngww vyfluhdfSk cssd. NkYk cNyhfqfspy css mZffspy xdW myyJ mjwF Nkwgll flLwh vyfluhdfs (Free electrons - clfUTld jsHthf gpizffggll vyfluhdfs) cssd. ,ej flLwh cyfluhdfis mZtypUeJ vspjy gphpjnjLffyhk (effyhk). flLwh vyfluhdfis mjpfk nfhzLss nghUlfis fljjpfs (Conductors) vdfpNwhk. rhjhuz ntggepiyfspy flLwh vyfluhdfs fljjp KOtJk vyyh jpirfspYk ruww Kiwapy ,aqFfpdwd. ,ej ruww ,affjjpd fhuzkhf› fljjpapd xUKidapypUeJ kwnwhU KidfF vttpjkhd epfu kpdJfsfs ghpkhwwKk ,UffhJ: vdNt kpdNdhllKk ,UffhJ. fljjpapd KidfSffpilNa kpdfyjjpd cjtpAld kpddOjj NtWghlil VwgLjjpdhy› flLwh vyfluhdfs kpdfyjjpd Nehkpdthia Nehffp ,OjJr nryyggLfpdwd. ,jd %yk epfu kpdNdhllk cUthfpwJ.

gjpndhdwhk tFgG ,awgpay Gjjfk njhFjp 2 myF 6 y ehk cah <hgG mOjjjjjypUeJ jho <hgG mOjjjjpwF epiwfs nrytijggwwp gapdNwhk. ,NjNghy Nehkpdjfsfs mjpf kpddOjjjjypUeJ Fiwej kpddOjjjjpwFk› vjphkpdJfsfs Fiwej kpddOjjjjypUeJ mjpf kpddOjjjpwFk nryfpdwd. vdNt kpdfyj njhFgG myyJ kpdfyk vdgJ fljjpapd KidfSffpilNa kpddOjj NtWghlil cUthfFtNj.

xU fljjpapy kpdNdhllk vdgJ nfhLffggll FWfF ntlL gugG A topahf kpdJfsfs ghAk tjk MFk.

tvdw Neujjpy xU fljjpapd VNjDk xU FWfFntlLggugG topahf ghAk kpdJfsfspd epfu kpdD}llk Q vdpy› mffljjpapy ghAk kpdNdhllk vdgJ

$I = \frac{Q}{t}$ MFk. vdDk xU fljjaiy kidJfsfsid Xllk vgNghJk khwyiahf ,Uggjyiy. vdNt nghJthf kidNdhlljij gidtUkhW tiuaiw nraayhk.

$I_{ruhrh} = \frac{DQ}{Dt}$

,qF ΔQ vdgJ Δt vDk Neu ,ilntsiaiy fljjaid VNjDk xU FWfF ntlLggugG toiahf ghAk kidJfsfsid kidD}ll msT MFk. Neujjijg nghWjJ kid Jfsfsid ghaT khwidhy› kidNdhllKk Neujijgnghujj khwwkilAk. vdNt kidNdhllk vdgJ ruhrh kidNdhlljjid vyiy kjigG MFk. ($\Delta t \to 0$)

$$I = \lim_{Dt \to 0} \frac{DQ}{Dt} = \frac{dQ}{dt}$$

kidNdhlljjid SImyF Mkgiah (A) MFk.

$1A = \frac{1C}{1s}$

xU $Y}k kidD}llk nfhzl kidJfsfs xU tidhb Neujjiy nrqFjjhd FWfFntlLggugigf flejhy VwgLk kidNdhllNk xU Mkgiah kidNdhllk MFk. kidNdhllk vdgJ]Nfyh msthFk.

vLjJfifhliL

xU jhkiuf fkgiay 1 eikiljjiwF 120C kidD}llk nfhzl kidJfsfs ghaejhy fkgi toiNa nryYk kidNdhlljjid kjigig fhzf

jhT

fkgiaiy kidNdhllk [kidJfsfsid ghAk tjk]

$I = \frac{Q}{t} = \frac{120}{60} = 2A$

kuG kidNdhlilk;

(kuG kidNdhlljjid jiir kwWk vyfluhd ghAk jiir)

xU kidRwwiy kidNdhllk ghAk jiiria Rlbffhll mkGfFwifs gadgLjjggLfidwd. kuGggb› kidRwwiy kidNdhllk Nehkid thaiyiUeJ vjhkidthAfF ghAk. ,ej kidNdhllNk kuG kidNdhllk myyJ kidNdhllk vdggLk. ,kkuG kidNdhlljjid jirNa Nrhjid Nehkidjfs (Positive test charge) nryYk jirahFk. Mdhy kidRwWfsiy czikaiy vyffluhdfNs vjhkidthaiyiUeJ Nehkidthaf F ghafidwd. vdNt vyfluhdfs nryYk jirAk› kuG kidNdhlljjid jirAk vjh vjhjjiraiy ,y csthW mikfidwd.

fzij hjahf ghhjjhy Nehkidjfsfs xU jiraiy nrytJ mjwFr rkkhd kidD}llk nfhzl vjhkidjfsfs vjhjjiraiy nrytjwFr rkkhFk.

kidNdhllkhdJ kidfy mLfFfshy klLk cwgjji nraaggLfidwd vdgjiyiy. ,awifaiy VwgLk kiddyntlL kiffFWfia fhyjjiy kif mjif kidNdhlljij VwgLjJk. kiddyidNghJ› NkffqfSfFk jiufFk (GtifFk) kif mjif msT kiddOjj NtWghL NjhdWtjhy Nkfqfsiyi UeJ jiufNfh (GtifF) myyJ jiuaiyiUeJ NkfjJfNfh kidJfs ghafiwJ.

,OgGjijjirNtfk

fljjpfspy ,UfFk flLwh vyfluhdfNs kpddD}lljij vLjJrnryYk Chjpfshfk. ,ej vyfluhdfs fljjp KOtJk vspjpy ,aqfp njhlheJ Nehkpd madpfs kJ NkhJk. ntspgGw kpdGyk (External Electric field) ,yyhj epiyapy› vyfluhdfs nttNtW jpirfspy nryfpdwd. vdNt mtwwpd jpirNtfqfSk nttNtwhdit. ntspgGw kpdGyk ,yyhj epiyapy ruhrhpahf VNjDk xU jpirapy gazpfFk vyfluhdfspd vzzpfifahdJ mjwF vjphjjpirapy gazpfFk vyfluhdfspd vzzpfiffF rkkhf mikAk. vdNt vej jpirapYk vyfluhdfspd epfu ,affk ,Uggjpyiy. vdNt xU fljjpapy ntspgGw kpdGyk ,yyhj epiyapy epfu kpdNdhllKk ,UffhJ.

fljjpapd KidfSffpilNa kpdfy mLfif ,izjJ kpddOjj NtWghlil cUthffpdhy fljjpaDs kpdGyk $\vec{E}$ cUthffggLk. ,ej kpdGyk vyfluhdfspd kJ tpiria VwgLjjp kpdNdhlljij cUthfFk. ,qF kpdGyk vyfluhdfis KLfFk Mdhy madpfs vyfluhdfis rpjwbjJ vyfluhdfspd ,aff jpiria khwWk. vdNt vyfluhdfspd ghij FWfF neLffhf mikAk. ,ej Nkhjypd fhuzkhf VwgLk FWfF neLfF ,affjJld $Ljyhf vyfluhdfs fljjp topNa $\vec{E}$,d jpirfF vjphjjpirapy xU Fwpggpll jpirNtfjjpy nkJthfr nryYk.

madpfs;

vej xU nghUSk vyfluhdfs kwWk GNuhllhdfid rkkhf vzzpfifapy nfhzL eLepiyj jdikAld mikAk. ntspfflby css vyfluhdfs mZit tplL ntspNawpdhy› mJ flLwh vyffluhdhf khwp kpdNdhlljij VwgLjJk. ntsptll vyfluhid ,oej mZ mjpf Nehkpd D}lljij nfhzbUfFk. vdNt mJ Nehkpd madp vdggLk. ,ej madpfs flLwh vyfluhdfis NghdW Rjejpukhf ,aqf ,ayhJ.

vyfluhdpd; ruww ,af;fKk› ,OgGj; jpirNtfKk;

,ejj jpirNtfk ,OgGj jpirNtfk $\overset{\rightarrow}{u_d}$ vdgLk. vdNt ,OgGjjpirNtfk vdgJ fljjpapy css vyfluhdfis kpdGyjjpwF clgLjJkNghJ mit ngWk ruhrhpj jpirNtfk MFk. mNjNghy ,U mLjjLjj Nkhjyfspfilggll ruhrhp Neuk vdgJ ruhrhp jshT Neuk t vdggLk. $\vec{E}$ vdw kpdGyjjpdhy vyfluhd ngWk KLffk $\vec{a}$ vdpy

$$\vec{a}=\frac{-e\vec{E}}{m} \quad (\text{Vnddpy } \vec{F}=-e\vec{E})$$

,OgGj jpirNtfk $\overset{\rightarrow}{u_d}$

$$\overset{\rightarrow}{v_d}=\vec{a}t$$
$$\overset{\rightarrow}{v_d}=\frac{et}{m}\vec{E}$$
$$\overset{\rightarrow}{v_d}=-m\vec{E}$$

,qF $m=\frac{et}{m}$ vdgJ vyfluhdfspd ,aff vz MFk. ,aff vz vdgJ xuyF kpdGyjjpdhy VwgLk ,OgGjjpirNtfjjpd vzkjpgG MFk.

$$m = \frac{\left|\vec{v}_d\right|}{\left|\vec{E}\right|}$$

,aff vz z‹d SImyF $m^2V^{-1}s^{-1}$

xU fljja‹y ,OgG j‹irNtfjj‹d nghJthd kj‹gG 10^{-4} ms^{-1} MFk. ,ej k‹frr‹wa j‹irNtfjj‹y vyfluhdfs nrdwhy› k‹d Rww‹y css k‹d t‹sfif mila gykz‹ Neuk MFk. g‹wnfggb k‹dfyjj‹d]t‹lir mOjj‹aTld k‹d t‹sfF xs‹hf‹wJ? k‹d fyjj‹d]t‹lR ,affggllTld vyfluhdfs k‹dfyjj‹d vj‹h k‹d Kida‹y‹UeJ t‹yf‹ efheJ mUf‹Yss vyfluhdfs kJ t‹iria VwgLjJk. ,ee‹foT fljj‹ to‹Na xs‹a‹d j‹irNtfjj‹y nryYk k‹dGyjij cUthfFk. mjhtJ k‹dfyjj‹y‹UeJ Mwwyhd k‹dt‹sff‹wF xs‹a‹d j‹irNtfjj‹y k‹dGyjj‹d %yk guTf‹wJ. ,jd fhuzkhf]t‹lir ,aff‹aTld k‹d t‹sfF xs‹hf‹wJ.

k‹dNdhl;lk; gww‹a jtwhd fUj;Jfs;

1. k‹dfyk vyfluhdfis k‹dRwWfF ms‹ff‹wJ vdw xU fUjJ e‹yTf‹wJ. ,J Kww‹Yk jtwhdJ. xU k‹dfyjij fkg‹a‹d ,U KidfSff‹ilNa ,izfFk NghJ› fkg‹a‹y css vyfluhdfNs k‹dNdhlljij cUthfFk. k‹dfykhdJ fljJk fkg‹a‹y k‹ddOjj NtWghlil e‹Wt‹ mjd %yk ,ej vyfluhdfis Fwgg‹ll j‹ira‹y ghar nraf‹wJ. ,ej k‹ddOjjNtWghlbd %yk NjhdWk k‹d Mwwyhd k‹dt‹sfF› k‹dt‹r‹w Kjy‹atww‹y gadgLf‹wJ. ,NjNghy ekJ tLfs‹y css k‹drhjdqfSf:F Njitahd k‹ddhwwiyjjhd k‹drhu thh‹ak toqFf‹wJ.

2. miyNgr‹ia gadgLjJkNghJ g‹dtUk thff‹aqfis ehk mdwhlk gadgLjJNthk. mit “vdDila miyNgr‹ k‹dfyjij k‹dNdwwk nraf‹Nwd” (Charging the battery in my mobile) kwWk vdDila miyNgr‹ k‹dfyjj‹y k‹dJfsfs ,yiy” (My mobile phone battery has no charge)” ,J Nghdw thff‹aqfs jtwhdit.

   miyNgr‹ k‹dfyjj‹y k‹dJfsfs ,yiy vdW nrhytjd nghUs ‘k‹dfykhdJ Mwwiyj ju ,ayt‹yiy myyJ k‹dRww‹y css vyfluhdfS fF k‹ddOjj NtWghlil ju ,ayt‹yiy” vdgjhFk. NkYk “miyNgr‹ k‹dNdwwk milf‹wJ” (mobile is charging) vdgj‹d nghUs miyNgr‹a‹d k‹dfykhdJ (Battery) AC k‹ddOjj %yjj‹y‹UeJ Mwwiy klLNk ngWf‹wJ vyfluhdfis myy vdgNj MFk.

k‹dNdhl;lj;j‹id Ez; khj‹h‹ (Microscopic model of current)

FWfF gugG A nfhzl fljja‹y k‹dGyk $\vec{E}$ MdJ tygGwjj‹y‹UeJ ,lJGwkhf nraygLf‹wJ vdf. NkYk XuyF gUkd‹y css vyfluhdfs‹d vz z‹fif *n* MFk. NkYk mit midjJk rkkhd ,OgGj j‹irNtfk $\vec{v}_d$ nfhzL ,aqFf‹dwd.

vyfluhdfs‹d ,OgGjj‹irNtfk = $v_d\,dt$ vDk r‹wa Neu ,ilnts‹a‹y vyfluhdfs *dx* njhiyTfF efhf‹wJ vd‹y

$$v_d = \frac{dx}{dt}; \qquad dx = v_d dt$$

fljja‹d FWfFntlLgugG *A* vd‹y› ,ggUkd‹y *dx* esjj‹y css vyfluhdfs‹d vz z‹fif

= gUkd × xuyF gUkd‹y css vyfluhdfs‹d vz z‹fif

$= Adx \times n$

c s s *dx* k j g i g r k d ghL g u j a l

$= (A\, v_d\, dt)\, n$

xU k f r r w a gUk d y (Volume element) c s s k d J f s f s d nk h j j k d D}l l k

dQ = (k d D}l l k) × (gUk f $w y c s s v y f l uh d f s d v z z f i f)

$dQ = (e)\, (Av_d\, dt)\, n$

v d N t k d N d h l l k $I = \dfrac{dQ}{dt}$

$I = ne\, Av_d$

k d N d h l l m l h j j (J)

k d N d h l l m l h j j v d g J f l j j a d x u y F F W f F n t l Lg gugG t o a h f ghAk k d N d h l l j j d m s t h F k.

$$J = \frac{I}{A}$$

k d N d h l l m l h j j a d SI m y F $\dfrac{A}{m^2}$ m j h t J $A\, m^{-2}$.

$$J = \frac{neAv_d}{A}$$

$$J = nev_d$$

Nkwf z l r k d ghL v d g J k d N d h l l j j d j i r a h d J gugG A t w F n r q F j j h f ,Uej h y k l LNk r h a h f m i k A k. ngh J t h f› k d N d h l l m l h j j xU n t f l h m s t h F k. , j i d g d t U k h W F w gg l y h k.

$$\vec{J} = ne\vec{v}_4$$

y UeJ $\vec{v}_4$ d k j g i g g u j a l y h k.

$$\vec{J} = \frac{n - e^2 t}{m}\vec{E}$$

$$\vec{J} = -s\vec{E}$$

, J t i u eh k v y f l uh d f s n r y Y k j i r i a f f z f f y v L j J f n f h z N l h k. m j d h y j h d NkNy c s s r k d gh l b y $\vec{J}$ M d J $\vec{E}$ f F v j h j j i r a y m i k f w J. M d h y k u Gggb› k d N d h l l m l h j j a d j i r a h d J Ne h k d J f s n r y Y k j i r a NyNa (k d G y j j d j i r) m i k A k. v d N t Nkwf z l g d t U k h W vO j ggL f w J.

$$\vec{J} = s\,\vec{E}$$

, q F $s = \dfrac{ne^2 t}{m}$ v d g J k d f l j J v z v d gg L k. X k t j j a d E z t b t k M F k.

k d f l j J v z z d j i y f o k j gG k d j i l v z (ρ) M F k.

$$r = \frac{1}{s} = \frac{m}{ne^2 t}$$

k d N d h l l m l h j j xU n t f l h m s T. M d h y k d N d h l l k xU] N f y h m s T V d? ngh J t h f k d N d h l l k *I* v d g J k d N d h l l m l h j j kwWk k d J f s f s ghAk gugG n t f l h M f a t ww d G s s gngU f f k M F k.

$$I = \vec{J}.\vec{A}$$

NkwgugG *A* t d n r q F j J n t f l h d j i r i a g ngh W j J k d N d h l l k *I* M d J

kpdNdhl;lk; xU]Nfyh;

Xk; tpjp

Xk tpjpahdJ J = σE vdw rkdghlbypUeJ ngwggLfpwJ. /esKk A FWfF ntlL gugGk nfhzl fkgpapd xU gFjpia fUJNthk.

fkgpapd KidfSffpilNa V vDk kpddOjj NtWghlil mspfFk NghJ› fkgpapy epfu kpdGyk Njhdwp kpdNdhlljij cUthfFk. fkgpapd esk KOtJk kpdGykhdJ ruhdjhf cssjhff fUjpdhy› kpddOjj NtWghL (NthyNl[) V ia gpdtUkhW vOjyhk.

$$V = EI$$

kpdNdhll mlhjjpapd vzkjpgG

$$J = \sigma E = \sigma \frac{V}{l}$$

mNjNghy $J = \frac{I}{A}$ vdNt gpdtUk vOjyhk.

Nkwfzl rkdghlil khwwp mikfFkNghJ› ekfF fpilggJ

$$V = I\left(\frac{l}{sA}\right)$$

\

,rrkdghlby $\frac{l}{sA}$ vdgJ fljjpapd kpdjil RMFk. ,jypUeJ ehk mwptJ› xU fljjpapd kpdjilahdJ fljjpapd esjjpwF NehjjftpYk› mffljjpapd FWfFntlLg gugGwF vjphjjftpYk mikfpwJ vdgNj. vdNt Xk tpjpapd gadghlL tbtjij gpdtUkhW vOjyhk.

$$V = IR$$

Nkwfzl rkdghlbdgb› fljjpapd kpdjil vdgJ fljjpapd KidfSffpilNa css kpddOjj NtWghlbwFk fljjpapd topNa kpdNdhlljjpwFk css jfthFk.

$$R = \frac{V}{I}$$

kpd jilapd SI myF Xk (Ω) rkdghL %yk ehk mwptJ› kpdNdhllk kwWk kpddOjj NtWghlbwFk (NthyNl[) ,ilggll tiuglk xU NehfNfhlhFk. ,ej NehNfhlbd rhaT kpdjil R d jiyfo kjpgGfFr rkkhFk.

xU nghUspd kJ nryYk kpdNdhllk kwWk mgnghUspd FWfNf css kpddOjj NtWghL Mfpa ,uzbwFkhd tiuglk NehfNfhlhf mikejhy› ,gnghUlfs Xk tpjpfF clgLk nghUlfs MFk.

kpdNdhllk kwWk kpddOjj NtWghlbwfhd tiuglk NehNfhlhf mikahky rpffyhd tbtpy ,Uejhy ,ttif nghUlfs myyJ fUtpfs Xk tpjpfF clgLtjpyiy. NkYk ,ttif nghUlfSfF kpdjil khwpyahfTk mikahJ.

kpdjil vz;

xU fljjpapd kpdjil

$$R = \frac{l}{sA}$$

vd KdgFjpapy fzNlhk. ,qF σ vdgJ mffljjpapd kpdfljJ vz MFk. ,J fljjp nraaggadgLk nghUspd jdikia klLNk rhhejJ. Mdhy fljjpapd msitNahf tbtjijNah nghWjjJ myy.

xU nghUspd kpdjil vz vdgJ mjd kpdfljJ vz zpd jiyfo kjpgGfFr rkkhFk.

$$r = \frac{l}{s}$$

l khwwp mikff

$$R = r\frac{l}{A}$$

vdNt xU nghUspd kpdjilahdJ mjd esjjpwF Nehjjftpyk. mgnghUspd FWfF ntlL guggpwF vjphjjftpyk mikAk.

NkNy fhZk rkdghlby css jfT khwpy; ρ MdJ nghUspd kpdjil vz vdggLk.

l = 1 m kwWk *A = 1 m²* vdpyf kpdjil R = ρ MFk. ,jid NtWtpjkhf $wpdhy nghUspd kpdjil vz vdgJ XuyF esKk XuyF FWfF ntlL gugGk nfhzl fljjpahdJ kpdNdhlljjpwF mspfFk kpdjil MFk. ,jd SI myF Xk - kllh (Ωm).

kpdjil vzizg nghUjJ nghUlfis fljjpfsf Fiwfljjpfsf kpd fljjhgnghUlfs (Insulators) vd tifggLjjyhk. fljjpfs kpff Fiwej kpdjil vzizAkf kpdfljjhgnghUlfs kpf mjpf kpdjil vzizAk kwWk Fiwfljjpfspd kpdjil vz fljjpfis tpl mjpfkhfTk Mdhy kpdfljjhg nghUlfis tp FiwthfTk mikAk.

rpy fljjpfsf kpdfljjhg nghUlfs kwWk Fiw fljjpfspd kpdjil vzfs juggllssd.

gyNtW nghUl;fspd; kpd;jil vz;

nghUlfs	20°C y kpdil vz ρ (Ωm)
kpd;fljjhg; nghUl;fs; (Insulators)	
J}a eh	2.5×10^{5}
fz zhb	$10^{10} - 10^{14}$
fbd ,uggh	$10^{13} - 10^{16}$
Nrhbak FNshiuL	10^{14}
cUfpa Fthhl]	10^{16}
Fiw fljjpfs; (Semi - conductors)	
n[hkhdpak	0.46
rpyffhd	640
fljjpfs; (Conductors)	
ntsspf	1.6×10^{-8}

jhkuk	17×10^{-8}
mYkdak	2.7×10^{-8}
lq]ld	5.6×10^{-8}
,UkG	10×10^{-8}

kdj clyy mjf msT eh cssjhy kdjil Fiwthf fllljjll 200 Ω msNt ,UfFk. NkYk cyhej Njhyd kdjil kf mjfkhf fllljjll 500 k Ω msT ,UfFk. Mdhy NjhyhdJ <ukhdjhf ,Uejhy kdjilad kjgG FiweJ fllljjll 1000 Ω msNt ,UfFk. vdNt kd ,izgGfis <ukhd iffSld njhLtJ kfTk Mgjjhdjhfk.

kdjilahffs njhlhizgG kwWk gfif ,izgG

xU kd Rwwy kf mjf vzzfifay kdjilahffs gyNtW tofsy ,izffgglbUfFk. xtnthU tif kdRwwYk kdjilahffsd ,izggwNfwg njhFgad kdjilia ehk fzfflyhk.

,uzL myyJ mjwF Nkwgll kdjilahffs xdwdgd xdwhf ,izggJ njhlhizgG MFk. ,it vsa kdjilahffshfNth myyJ kdtsfFfshfNth (light bulb) myyJ ntggNkwWk rhjdqfshfNth myyJ NtW kdrhjdqfshfNth mikayhk. R_1, R_2 kwWk R_3 Mfa kdjilahffs njhlhizggy cssd.

kdJfsfs kdRwwy vqFk Nrfukhfhj vdgjhy R_1 y ghAk mNj msT kdJfsfNs R_2 kwWk R_3 tohfTk ghAk. vdNt› vyyh kdjilahffsYk xNu msthd kdNdhllNk *(I)* ghAk.

Xk tjggb xNu msTss kdNdhllk njhlhizggy css nttNtW kjgGila

kdjilahffs tofNa ghAk NghJ› kdjilahffsd FWfNf cUthFk kddOjj NtWghLfs khWgLk.

V_1, V_2 kwWk V_3 vdgd KiwNa R_1, R_2 kwWk R_3 kdjilahffsy FWfNf css kddOjj NtWghLfs (NthyNl[) vdy› $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$ MFk. Mdhy nkhjj kddOjj NtWghL V MdJ kdjilahffsd FWfNf css jdjjd kddOjj NtWghLfsd $LjYfFr rkkhFk.

$$V = V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3$$
$$V = I(R_1 + R_2 + R_3)$$
$$V = IR_s$$

,qF R_s vdgJ njhFgad kdjiliaf Fwffwj.

$$R_s = R_1 + R_2 + R_3$$

vdNt gy kd jilahffs njhlhizggy cssNghJ› nkhjj myyJ njhFgad kdjilahdJ jdjjd kdjilfsd $LjYfFr rkkhFk.

FwgG: njhlhizggy css kdjilahffsd njhFgad kdjilahdJ jdjjd kdjilfsd kjgGfis tl mjfkhf mikAk.

gfif ,izggy kdjilahffs

xU kddOjj NtWghlbd FWfNf gy kdjilahffifis ,izjjhy mit gff ,izggy cssd vdyhk.

,ttif RwWfsy› kdfyjjyUeJ ntsNaWk nkhjj kdNdhllk I MdJ %dW ghijfsy gfwJ. R_1, R_2 kwWk R_3 toNa ghAk kdNdhllqfs KiwNa I_1, I_2 kwWk I_3 vdf. kddD}llqfsd khwhtjggb nkhjj kdNdhllk I MdJ ,kkdjilahffifs toNa ghAk kdNdhllqfsd $LjYfFr rkkhFk.

$$I = I_1 + I_2 + I_3$$

NkYk xtnthU kdjilahffifFk FWfNfAk css kddOjNtWghLk rkk vdgjhy› xtnthU kdjilahffifFk ehk Xk tjpia gadgLjjyhk.

$$I_1 = \frac{V}{R_1}, I_2 = \frac{V}{R_2}, I_3 = \frac{1}{R_3}$$

,kkjpgGfis gujpal

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{1}{R_3} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$I = \frac{V}{R_p}$$

gf;f ,izggy; kd;jilfs;

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

,qF R_P vdgJ gff ,izggy css kdjilahffifsd njhFgad kdjil MFk. vdNt gy kdjilahffifs gff ,izggy ,izffggLkNghJ› jdpjjdp kdjilfsd jiyfo kjpgGfsd $Ljy› njhFgad kdjilad jiyfo kjpgGfFr rkk.

FwpgG:
gff ,izggy kdjilahffifs ,izffggLk NghJ njhFgad kdjil jdpjjdp kdjilfsd kjpgig tpl Fiwthdjhf ,UfFk.

tlL cgNahf rhjdqfs vgNghJk gff ,izggy ,izffgglbUfFk. mgNghJjhd VjhtJ xU rhjdk gOjilejhy mijjjtpjJ kww rhjdqfs Ntiy nraAk.

fhhgd; kd;jilahf;fpfspy; epwf;FwaLfs;

fhhgd kdjilahffifspy gqfhd cssfjjd kJ nkyypa fhhgd gbfk thhffgglbUfFk ,ej kdjilahffifs nryT Fiwthdjhfftk rwpa mstpYk› ezl ehs cioffF$badthfTk mikfpdwd. kdjilahffifsd kjpgigffhd mjd kJ tiuaggll epw tisaqfs gadgLfpdwd.

Kjy ,uzL tisaqfs kdjilad Kffpa vz ZUffshfTk› %dwhtJ tisajjpwFhpa vz FwpaL gjjpd mLfF ngUffyhfTk mikAk. ehdfhtJ tisak kdjil khWgLk msit (Tolerance) FwpfFk.

kd;jilfspy; epw tisaqfs;

e¤wk¡	v z¡	ngUf¡f msT	khWgLk¡ msT (tolerance)
fUgG	0	1	
gOgG	1	10^1	
r¤tgG	2	10^2	
MuQR	3	10^3	
kQrs	4	10^4	
grir	5	10^5	
eyk	6	10^6	
Cjh	7	10^7	
rhkgy	8	10^8	
ntsis	9	10^9	
jqfk		10^{-1}	5%
		10^{-2}	10%
			20%

ehdfhtJ tisak ,lk ngwt¤yiynad¤y khWgLk msT 20% MFk.

k¤djilahff¤a¤y› Kjy ,yffk = 5 (grir)› ,uzlhtJ ,yffk = 6 (eyk)› gjjbkhd ngUffk = = 10^3 (MuQR) kwWk khWgLk msT = 5% (jqfk). k¤djilahff¤a¤d kj¤gG = 56×10^3 Ω myyJ 56 kΩ kwWk khWgLk msT 5%.

k¤djilfs¤d e¤wfFw¤aLfis fhZk NghJ %dW tisaqfs css gFj¤ ekfF ,lJ Gwk ,UfFkhW itjJfnfhss Ntz Lk. k¤djilfs¤y cNyhf e¤w tisaqfs ,lJ Gwkhf ,UffhJ.

ntgge¤iyiar¡ rhhe¤j k¤dj¡il vz¡
nghUlfs¤d k¤djil vz ntgge¤iyiar rhheJ mikAk. guej ntgge¤iy neLffqfSfF› flj¡fs¤y ntgge¤iy caUkNghJ k¤djil vz mj¤fh¤fFk vz MaTfs %yk e¤&g¤ffgglLssJ. ,jid g¤dtUk rkdghL %yk mw¤ayhk.

$$\rho_T = \rho_0 [1+\alpha(T-T_0)]$$

,qF ρ_T vdgJ T°C ntgge¤iya¤y k¤djil vz› ρ_0 vdgJ T_0 ntgge¤iya¤y mjd (ck 20°C) k¤djil vz kwWk *a* vdgJ k¤djil ntgge¤iy vz (Temperature coefficient of resistivity) MFk.

k¤djil ntgge¤iy vz vdgJ xU bf¤h¤ ntgge¤iy caht¤y VwgLk k¤djil vz mj¤fh¤ggwFk T_0 ntgge¤iya¤y css k¤djil vz ZfFk ,ilNa css t¤f¤jk MFk.

y¤UeJ $\rho_T - \rho_0 = \alpha\rho_0 (T - T_0)$ vd vOjyhk.

$$\therefore a = \frac{r_T - r_0}{r_0(T - T_0)} = \frac{\Delta r}{r_0 \Delta T}$$

,qF $\Delta\rho = \rho_T - \rho_0$ vdgJ $\Delta T = T - T_0$ vDk ntgge¤iy khWghllhy VwgLk k¤djil vz khWghL MFk. ,jd myF /°C MFk.

flj¡j¤fSf¡fhd k¤dj¡il ntgge¤iy vz¡ *a*

fljjpfSfF a NehfFwpAilaJ. fljjpfspd ntggepiy mjpfhpfFk NghJ> fljjpay css vyfluhdfspd ruhrhp ,aff Mwwy mjpfhpfFk. ,jd tpisthf Nkhjyfspd vz zpfif mjpfhpjJ kpdjil vz Zk mjpfhpfFk.

fljjpfspYk cNyhfqfisg Nghy guej ntggepiy msTfSfF kpdjil vz Nehtpfpjj jdikAld (linear) ,UggpDk> kpffFiwej ntggepiyfspy Neh tpfpjkwwj jdikAk fhzggLk.

ntggepiy kjpgg jdpRo ntggepiyia (absolute temperature) neUqFkNghJ kpdjil vz xU Fwpggpll tiuaWffggll kjpgigg ngWk.

$r = R\frac{A}{l}$ vdw Nfhitia gpujpaplL> xU Fwpggpll ntggepiyapy fljjpapd kpdjilia gpdtUk rkdghlbd %yk Fwpggplyhk.

$$R_T = R_0\,[1+a\,(T-T_0)$$

kpdjil ntggepiy vz izg ngwyhk.

$$R_T - R_0 = aR_0(T - T_0)$$

$$\therefore a = \frac{R_T - R_0}{R_0(T - T_0)} = \frac{1}{R_0}\frac{DR}{DT}$$

$$a = \frac{1}{R_0}\frac{DR}{DT}$$

,qF $\Delta R = R_T - R_0$ vdgJ $\Delta T = T - T_0$ vDk ntggepiy khwwjjpy VwgLk kpdjil khWghL MFk.

Fiwfljjpfspd; a kjpgG

Fiwfljjpfspy> ntggepiy mjpfhpjjhy kpdjil vz FiwAk. ntggepiy caUkNghJ Fiwfljjpfspy kpdNdhllk gwwp tpthpffgglLssJ. Fiwfljjpapd mZffspy ,UeJ mjpf vz zpfifapy vyfluhdfs tpLgLk.

,jdhy kpdNdhllKk mjpfhpfFk. mjdhy kpdjil FiwAk. vjphfFwp ntggepiy kpdjil vz cila FiwffljjpahdJ ntgg jilafk (Thermistor) vdggLk.

nghUlfspd kpdjil ntggepiy vz fspd kjpgGfs juggllssd.

nghUl;fs;	kpd;jil ntggepiy vz; a[(°C)$^{-1}$]
ntsspp	3.8×10^{-3}
jhkpuk	3.9×10^{-3}
jqfk	3.4×10^{-3}
mYkpdpak	3.9×10^{-3}
lq]ld	4.5×10^{-3}
,UkG	5.0×10^{-3}
gpshlbdk	3.92×10^{-3}
fhhak	3.9×10^{-3}

e‰fNuhk	0.4×10^{-3}
fhhgd	-0.5×10^{-3}
n[hkhd‰ak	-48×10^{-3}
r‰y‰ffhd	-75×10^{-3}

g‰dtUk fUjj‰d %yk k‰djil vz ntgge‰iyia rhheJ ,Uggij Gh‰eJ nfhssyhk. k‰d fljJ vz $s = \frac{ne^2t}{m}$ vdf fzNlhk. k‰djil vz MdJ σ t‰d jiyfo k‰j‰gghFk. ,jid foffzlthW vOjyhk.

$$r = \frac{m}{ne^2t}$$

nghUlfs‰d k‰djil vz MdJ.

1. vyfluhdfs‰d vz mlhjj‰ *(n)* fF vj‰hjjft‰y mikAk
2. NkhjYfF ,ilggll ruhrh‰ fhyjj‰wF (τ) vj‰hjjft‰y mikAk

fljj‰a‰y ntgge‰iy mj‰fh‰fFk NghJ τ Fiwf‰wJ› *n* khw‰y‰ahf ,Uff‰wJ. Mdhy Fiwfflj‰a‰y ntgge‰iy mj‰fh‰fFk NghJ *n* mj‰fh‰ff‰wJ› Fiwf‰wJ. ,qF τ Fiwitt‰l *n* ,d mj‰fh‰gG Mj‰ffk cssJ vdgjhy xlLnkhjjkhf k‰djil vz FiwAk.

xU r‰y nghUlfs‰d ntgge‰iyahdJ xU Fw‰ggll ntgge‰iyfF fNo FiwAkNghJ mjd k‰djil vz Ro‰ahFk. ,ej ntgge‰iyahdJ khWe‰iy ntgge‰iy myyJ ngahT ntgge‰iy vdggLk. ,ej e‰fot‰id nts‰ggLjJk nghUlfs kfflj‰fs (Superconductors) vdggLk. Kjd Kjy‰y 1911 y fhkhy‰q xd] vdgth ghjurkhdJ 4.2 K ntgge‰iya‰y kffljJk jdikia nts‰ggLjJtijf fzlwejhh. ,ej kfflj‰fs‰y k‰djil R = 0 vdgjhy ,j‰y xU Kiw nrYjjggLk k‰dNdhllk vtt‰j k‰ddOjj NtWghLk ,dw‰ jqf‰a‰UfFk.

k‰d; Rw‰Wfs‰y; Mw‰wy; kw‰Wk; j‰wd;

fljj‰a‰d KidfSff‰ilNa k‰dfyjij ,izfFk NghJ› k‰dNdhllk ghaf‰wJ. k‰dRww‰y ,izffggll fUt‰fF k‰dfykhdJ Mwwiy ms‰ff‰wJ. k‰ddOjj NtWghL *V* nfhzl k‰dfykhdJ k‰djilahff‰Ald ,izffggll k‰dRwW

dQ k‰dD}llk css Neh k‰dJfsfshdJ Gss‰ *a* t‰y‰UeJ *b* fF k‰dfyk to‰ahfTk› Gss‰ *c* y‰UeJ *d* fF k‰djilahff‰ to‰ahfTk efheJ kzLk Gss‰ *a* it miltjhf nfhsNthk.

a t‰y‰UeJ *b* fF k‰dJfsfs efUkNghJ ,kk‰dJfsfshdJ *dU* = *V.dQ* msT k‰ddOjj Mwwiy ngWf‰wJ. ,jdhy k‰dfyjj‰d Ntj‰ k‰ddOjj Mwwy ,Nj msT Fiwf‰wJ. *dQ* msT k‰dD}llk css k‰dJfsfs k‰djilahff‰ to‰ahf ghaeJ *a* it milAkNghJ k‰djilahff‰a‰y css mZffs‰d kJ Nkhj‰ *dU* msTss k‰ddOjj Mwwiy ,off‰wJ. k‰dfykhdJ› k‰dRww‰y ,izffgglbUfFk tiu ,ee‰fothdJ njhlheJ eilngwW nfhzbUfFk. k‰dJfsfs k‰djilahff‰a‰y vttsT Ntfjj‰y k‰ddOjj Mwwiy ,off‰wJ

kddOjj Mwwy msffggLk tjk kdjwd PvdggLk.

$$P = \frac{dU}{dt} = \frac{(V.dQ)}{dt} = V\frac{dQ}{dt}$$

$I = \frac{dQ}{dt}$ vdgjyUeJ rkdghL gdtUkhW khww vOjyhk.

P = VI

,qF I vdgJ kdNdhllk kwWk V vdgJ kdrhjdjjd FWfNf css kddOjj NtWghL MFk. Nkwfzl rkdghL kdrhjdjjwF kdfyjjd %yk msffgglij jwdd kjgG MFk.

kdjwdd SImyF thl (IW = 1 Js^{-1}) tzf ujahf› ekJ ,yyqfsy gadgLk kd gyGfsy Fwggllss jwd kwWk kddOjj NtWghL Mfawwd kjgGfs 5W – 220 V, 30 W – 220 V, 60W – 220 V MFk. ,itfs filfsy fiilffdwd.

,ej gyGfsy Fwggllggk kddOjj NtWghLfs nghJthf RMS khWjir kddOjjNtWghlilNa (RMS AC Voltage) FwfFk. Fwggggllss kddOjj NtWghlil tl gygd FWfNf mjf kddOjjk nfhLffgglhy kdgygd ,io JzbffggLk (Fuse).

Xk tjpia gadgLjj› kdjil R fF msffggLk jwDffhd rkdghlil gdtUkhW vOjyhk.

kdjilay cUthffggLk (ntsNaWk) kdjwdd msT $P = I^2R$ MFk. ,jd %yk ehk mwtJ› kdjwdhdJ kdNdhlljjd ,Ukbia nghWjjJ. vdNt kdNdhlljij ,Uklqfhffdhy kdjwdhdJ ehdF klqfhFk. kddOjj NtWghlbwFk ,ej tsffk nghUeJk.

xU kdrhjdk gadgLjJk nkhjj Mwwiyg ngw mjd jwd kwWk mrrhjdk ,aqFk Neu mstd ngUfFj njhifia fhz NtzLk. jwd thl (W) vdw myfYk› fhyk tehbaYk mstlggLtjhy MwwyhdJ fhyk tehbaYk mstlggLtjhy MwwyhdJ [{y vdw myfy Fwggllggk. eilKiway kd Mwwiy mstl fNyh thl kz (kWh) vdw myF gadgLjjggLfwJ. 1 KWh vdgJ kd Mwwyd 1 myF (one unit) MFk.

(1 kWh = 1000 Wh = (1000 W) (3600 s) = 3.6×10^6J)

jkoehL kdrhu thhak ehk gadgLjJk kd MwwYffhd fllzjij ngWfwNj jtu kdjwDffhd fllzk myy. IV kddOjj NtWghlbdhy 1 A vdy cUthFk jwd 1W MFk.

kd;fyqfSk; kd;fyj; njhFgGfSk;

kdfyk vdgJ Ntj Mwwiy kd Mwwiy kd Mwwyhf khww kdNdhlljij VwgLjJk rhjdk MFk. ,jy ,U kdjzLfs kdgFjay (electrolyte) %of itffgglLssij fhzyhk.

kdfyjnjhFgG (Battery) vdgJ gy kdfyqfs (Cells) ,izffggll mikgG MFk. xU kdfyk myyJ kdfyjnjhFgig ,izfFkNghJ› vyfluhdfs vjhkdKidaiyUeJ Nehkd KidfF kdRwW toNa ghAk. Ntj t idfsd %yk› kdfyjnjhFgG myyJ kdfyk kdKidfSffilNa kddOjj

NtWghlil cUthfFk. ,ej kddOjj NtWghNl vyfluhdfis kd Rwwy efhjj Njitggk Mwwiy msfFk. tzf ujahf filfsy filfFk kdfyqfs kwWk kdfyjnjhFgGfis fhlLfwJ.

kd; ,af;F tir kwWk; mf kd;jil

xU kdfyk myyJ kd fyjnjhFgG vdgJ kddafF tir (emf) %ykhFk. kddafF tir vdgJ czikay tirayy. ,J kddOjj NtWghlbd myfhd NthylbNyNa FwffggLfwJ. xU kdfyk myyJ kdfyj njhFggy css kddafF tir vdgJ Gwr Rwwy kdNdhllk ghahj NghJ mjd kdKidfSfF ,ilNa css kddOjj NtWghlil Fwffwj.

kddafF tir vdgJ› kdfyj njhFgghdJ kdRwwy xuyF kdD}llk nfhzl kdJfsfis efhjj Njitggk Ntiyad msitf Fwffwj. ,jd FwaL ε MFk. xU ,ylra kdfyjnjhFggd mfkdjil Ro (Internal resistance)

MFk. vdNt kdfyj njhFggd kdKidfSffilNa css kddOjj NtWghL vdgJ mjd kddafF tirfF rkk. Mdhy eilKiway xU kdfyj njhFgghdJ kdjzLfs (electrodes) kwWk kd gFsahy (electrolyte) MdJ. ,jdhy kdfyjjDs kdJfsfsd Xlljjwf jil ,UfFk. ,ej kdjilNa mfkdjil r vdggLk. vdNt eilKiway css kdfyj njhFggy kdKidfSffilNa css kddOjj NtWghL kddafF tirfF rkkyy. Gjajhf cUthffggll kdfyjjd mfkdjil Fiwthf ,UfFk. mjd gadghL mjfhff mjfhff (ehshf) mfkdjil mjfhfFk.

mfkd;jiliaf; fzf;fLjy;

cssthW kdRwwy ,izgGfs juggLfwJ.

kdfyjjd kddafF tir ε l fzlwa mjd FWfNf cah kd jil nfhzl Nthylkllh ,izffggLfwJ. ,qF Gwkdjilahffi R ,izffgglf$lhJ. Nthylkllh kff Fiwej msNt kdNdhlljij vLjJfnfhstjhy ,rRwW jwej Rwwhf fUjggLk. vdNt Nthyl kllh fhlLk msT vdgJ kdfyjjd kddafF tiraid msNt. R vdw Gwkdjilahffia kdRwwy ,izjjhy l vdw kdNdhllk Rwwy cUthffggLk. NkYk R d FWfNf css kddOjj NtWghL kdfyjjd

kd;fyj;jd; mfkd;jil FWfNf css kddOjj NtWghlbwFr rkkhFk (kddafF tirfFr rkkyy).

R kdjilahffiad FWfNf css kddOjj NtWghL

$$V = IR$$

mfkdjil r d fhuzkhf› Nthyl kllh fhlLk V d kjgG kddafF tir ε l tl Fiwthf ,UfFk. ,jwF fhuzk Ir vdw kddOjj NtWghL r ,d FWfNf VwgLtNj MFk.

,jdhy $V = \varepsilon - Ir$

$$Ir = \varepsilon - V$$

$$\frac{Ir}{IR} = \frac{e - V}{V}$$

$$r = \left[\frac{e - V}{V}\right] R$$

ε, V kwWk R Mfpaitfspd kjpgGfs njhptpAk vdgjhy> mfkpdjil (r) I fzffplyhk. mNjNghy kpdRwwpy css nkhjj kpdNdhlljijAk fzffplyhk.

mf kpdjil fhuzkhf> kpdRwWfF mspffggLk jpwd kpdfyjnjhFggpy Fwpggplgglss jpwDfF rkkhf ,UffhJ. msT kpddpafF tpirAk r msT mfkpdjilAk nfhzl kpdfyk R kpdjil nfhzl kpdRwWfF mspfFk jpwDffhd Nfhit kpdtUkhW vOjggLfpwJ.

$P = I\varepsilon = I(V + Ir)$

,qF V vdgJ R d FWfNf css kpddOjj NtWghL. ,J IR fFr rkk.

vdNt> $P = I(IR + Ir)$

$$P = I^2R + I^2r$$

,qF I^2r vdgJ mfkpdjilfF mspffggll jpwd kwWk I^2R vdgJ R vdw kpdjilfNfh (myyJ) gadgLjjggLk kpd rhjdjjpwNfh mspffggLk jpwdhFk.

xU rpwej kpdfyjnjhFggpwF mfkpd jil r kpf FiwT vdgjhy $I^2r << I^2R$ MFk. vdNt fpllijll xlLnkhjj jpwDk kpdjil R fF mspffggLk.

kpdfyqfs njhlhpizgG:

gy kpdfyqfs ,izffgglL kpdfyj njhFgG cUthffggLk. njhlhpizggpy Kjy kpdfyjjpd vjph kpdKid ,uzlhtJ kpdfyjjpd Nehkpdkidalk> ,uzlhtJ kpdfyjjpd Nehkpd KidAlDk ,izffggLk. ,izffgglhj Kjy kpdfyjjpd Nehkpd Kid kwWk ,izffgglhj filrp kpdfyjjpd vjph kpdKidfNs kpdfyjnjhFggpd kpd Kidfshf mikAk.

mfkpdjilAk> ε kpddpafF tpirAk nfhzl n kpdfyqfs R vdw GwkpdjilahffpAld njhlhpizggpy ,izffgglLssd.

kpdfyqfs - njhlhpizgG kpdfyj njhFggpd nkhjj kpddpafF tpir = nε

kpdRwwpd nkhjj kpdjil = nr + R

Xk tpjpapd gb> kpdRwwpd kpdNdhllk =

$$I = \frac{\text{nkhjj kpddpafF tpir}}{\text{nkhjj kpdjil}} = \frac{ne}{nr + R}$$

epiw *(a) r <<R,* vdpy

$$I = \frac{ne}{R} \approx nI_1$$

,qF vdgJ xU kpdfyjjpd VwgLk kpdNdhllk

$$\left(I_1 = \frac{e}{R}\right)$$

vdNt R lg nghWjJ r kpffFiwthf Gwffzpff jfff msT ,Uggpd kpdfyjnjhFgG VwgLjJk kpdNdhllk xU kpdfyk VwgLjJk kpdNdhlljij NghdW n klqF mikAk.

epiy (b) r >> R, vdpy $I = \frac{ne}{nr} \approx \frac{e}{r}$

,J xU kpdfyk VwgLjJk kpdNdhllk MFk. vdNt kpdfyjnjhFggpd kpdNdhllKk xU kpdfyjjpd kpdNdhllKk rkk MFk. ,eepiy gadwwJ.

vdNt njhlhpizggpy kpdfyqfs ,izffggLkNghJ kpdfyqfspd njhFgad mfkpdjil Gwkpd jilia tpl kpffrwpa kjpgghf cssNghJ klLNk gaDssjhf ,UfFk.

gfpf ,izggpy kpdfyqfs

gff ,izggpy vyyh kpdfyqfspd Neh kpdKidfSk xU Gsspay ,izffggLk. ,NjNghy vyyh vjph kpdKidfSk kwnwhU Gsspay ,izffggLk. ,ej ,U GsspfSk KiwNa kpdfyjnjhFggpd Neh kwWk vjhkpdKidfshf mikAk.

A kwWk B GsspfSffpilNa n kpdfyqfs gff ,izggpy R vdw Gwkpdjilahffpld ,izffgglLssd.

kpdfyj njhFggpd njhFgad mfkpdjil

$$\frac{1}{r_{eq}} = \frac{1}{r} + \frac{1}{r} + ... \frac{1}{r} \text{ (n \$Wfs)} = \frac{n}{r}$$

$r_{eq} = \frac{r}{n}$ kpdRwwpd nkhjj kpdjil = $R + \frac{r}{n}$. nkhjj kpddpafF tpir vdgJ A kwWk B GsspfSffpilNa css kpddOjj NtWghL MFk. ,J εfF rkk. Rwwpy css kpdNdhllk

$$I = \frac{e}{\frac{r}{n} + R}$$

$$I = \frac{ne}{r + nR}$$

epiy (a) r >> R, vdpy $I = \frac{ne}{r} = nI_1$

,qF R Gwffzpffjjff msT cssNghJ I_1 vdgJ xNu xU kpdfyjjpdhy VwgLk kpdNdhllk. ,J $\left(\frac{e}{r}\right)$ fFr rkk. vdNt kpdfyj njhFggpdhy R topNa VwgLk kpdNdhllk xNu xU kpdfyjjpdhy VwgLk kpdNdhlljij Nghy n klqF mikAk.

epiy (b) r << R, vdpy $I = \frac{e}{R}$

ehk mwptJ kpdfyjnjhFggpdhy vwgLk kpdNdhllk xNu xU kpdfyjjpdhy VwgLk kpdNdhlljjwFr rkk. vdNt kpdfyqfspd gff ,izggpy ,izfFk NghJ Gwkpd jilahdJ kpdfyqfspd mfkpdjilia tpl Fiwthf ,Uejhy klLNk gaDssjhf mikAk.

fhhy KfgG tsfF vhAk eiyay vd[id ,afFk NghJ› KfgG tsffd nghyT rwJ FiwAk. ,jwF fhuzk fhhy css kdfyjjd mfkd jil MFk.

fhf;fh/g; tjjfs; (Kirchhoff's Rules)

Xk tjp vsa kdRwWfSfF klLNk gadgLk. rffyhd kd RwWfsy kdNdhllk kwWk kddOjj NtWghlil fzffl fhffh/g tjjfs gadgLjjggLfdwd. mit

1. fhffh/g kdNdhll tjp
2. fhffh/g kddOjj NtWghlL tjp MFk

fhf;fh/g; Kjy; tjp (kdNdhl;lt jp myyJ rejp tjp):

vej xU rejpaYk rejpffdw kdNdhllqfsd Fwapay $lLjnjhif (Algebraic sum) RoahFk. ,J kdJfsfsy css kdD}llqfsd motdik tjpaid mbggilay mikfwJ. rejpfsy kdJfsfs cUthffggLtNjh motNjh ,yiy. mjhtJ rejpay EioAk kdJfsfs midjJk rejpia tlL ntsNaWk. fhffh/g Kjy tjpiag gadgLjJk NghJ rejpia Nehffr nryYk kdNdhllk NehfFw vdTk rejpia tlL ntsNaWk kdNdhllk vjhfFw vdTk vLjJfnfhssggLk.

A rejpfF ,t tjpia gadgLjj

$$I_1 + I_2 - I_3 - I_4 - I_5 = 0$$

myyJ

$$I_1 + I_2 = I_3 + I_4 + I_5$$

fhf;fh/g; ,uz;lhtJ tjp (kd;ddOj;j NtWghl;L tjp myyJ RwW tjp)

,t tjpapdgb vejnthU %ba Rwwd xtnthU gFjpaYk css kdNdhllk kwWk kdjil Mfpatwwd ngUffwgydfsd Fwapay $lLj njhifahdJ› mej kdRwwy css kddafF tpirfsd Fwapay $lLjnjhiffFr rkk. ,ej tjp jdjj mikggd Mwwy khwh tjpggb mikfwJ. mjhtJ kddafF tpir %yk msfFk Mwwyhd vyyh kdjilahffpfs ngWk Mwwyfsd $LjYfFr rkkhFk. %ba Rwwy (Closed loop) ehk nryYk jpirtoNa kdNdhllk nrdwhy› mkkdNdhllk kwWk mgghijay css kdjil Mfpatwwd ngUffwgyd kjpG NehfFwahfTk› %ba Rwwy ehk nryYk jpirfF vjhjjpiray kdNdhllk nrdwhy› mkkdNdhllk kwWk mgghijay css kdjil Mfpatwwd ngUffwgyd kjpG vjhfFw kjpgghfTk vLjJfnfhssggLk. ,NjNghy %ba Rwwy ehk nryYk jpirapd topNa kdfyjjpd vjhkd Kidaypueh Nehkd Kid toahf ehk nryYk NghJ kddafF tpir NehfFwahfTk mNjNghy

kdfyjjpd Neh kd Kidaypueh vjhkd Kid toahfr nryYk NghJ kddafF tpir vjhfFwahfTk vLjJf nfhssggLfwJ.

fhffh/g kddOjj NtWghlL tjpia gadgLjJkNghJ Rwwy css midjJ kdNdhllqfSk epiyahd kjpgig ngw Ntz Lk vDk egejid gdgwwggl Ntz Lk

tll;]Nlhd; rkdr; RwW

fhffh/g tjpfsd Kffpa gadghlhf tl]Nlhd rkdr RwW mikfwJ. kdRwW tiy (electrical networks) mikgGfsy tl]Nlhd rkdrRwwd %yk njhahj kdjilahffpad kjpgig fzlwaTk› kdjilahffpfis xggpl Tk KbAk.

,ej tiy mikggy P, G, R kwWk Skdjilahffyfs csssthW ,izffgglLssd. G vdw fhytdh klluhdJ B kwWk D Gssyfsffyilna ,izffgglLssJ. fhytdh kllh toyNa

tll;]Nlhd; rkdr; RwW

ghAk kydNdhllk I_G vdTk mjd kydjil *G* vdTk vLjJf nfhssggLfywJ.

B rejyfF fyhffh/g kydNdhll tyjyia gadgLjj›

$$I_1 - I_G - I_3 = 0$$

D rejyff fyhffh/g kydNdhll tyjyia gadgLjj›

$$I_2 + I_G - I_4 = 0$$

ABDA vdw %ba RwWfF fyhffh/g kyddOjj NtWghlL tyjyia gadgLjj

$$I_1P + I_GG - I_2R = 0$$

ABCDA vdw %ba RwWfF fyhffh/g kyddOjj NtWghlL tyjyia gadgLjj›

$$I_1P + I_3Q - I_4S - I_2R = 0$$

B kwWk D Gssyfs rkkyddOjjjjy ,Uejhy› tl]Nlhd rkdrRwW rkeyiyay ,UfFk. B kwWk D Gssyfsffyilna kyddOjj NtWghL ,yiy vdgjhy› fhytdh kllh toyNa kydNdhllk ghahJ. ($I_G = 0$) vdNt $I_G = 0$ vd rkdghLfs kwWk ,y gyujyal

$I_1 = I_3$

$I_2 = I_4$

$I_1P = I_2R$

rkdghL

$I_3Q = I_4S$

rkdghL

$$\frac{P}{Q} = \frac{R}{S}$$

,JNt tl]Nlhd Rwwyd rkeyiyffhd eygejid MFk. ,ej eyiyay klLNK fhytdh kllh Roy tyffjij fhlLk. mUfUNf csss ,U kydjilahffyfsyd kjygG ekfF njhytjhff nfhzlhy› kww ,U kydjilahffyfis xggylyhk. NkYk ehdF kydjilahffyfsy %dwyd kjygG njhyejhy njhyahj ehdfhtJ kydjilahffyayd kjygigAk ,jd %yk fzffyl KbAk.

fhytdh kllh vdgJ kydNdhlljij fzlwyaTk mstylTk cjTk xU rhjdk MFk. kyfrrwya msT kydNdhllqfis mstyl ,jid gadgLjj KbAk. xU kydRwwyd nttNtW gFjyfsy csskyddOjj NtWghlil xggylTk ,J ngUksT gadgLjjggLfywJ.

kll;lh; rkdr;RwW:

kllh rkdr RwW vdgJ tl]Nlhd rkdrRwwyd ,dndhU tbtk MFk. ,jy 1 kllh esKss AB vdw ruhd Nkqfdyd (Manganin) fkgy cssJ. ,ffkgy xU kllh msT NfhYfF ,izahf xU kuggyifayy C kwWk D vdw ,U jhkyu glilfSfF ,ilNa ellgglLssJ. ,U jhkyugglilfSfF ,ilayy E vdw kwnwhU jhkyu glil G_1 kwWk G_2 vdw ,U ,ilntsyfsyy nghUjjgglLssJ. G_1

,ilntsyay kjygG njhyahj kydjilahffy P Ak G_2 ,ilntsyay vdw gbjju (njhyej) kydjilahffy Q k ,izffgglLssd. xU njhLrhtyahdJ (kydfljjy) ika jhkyugglilayy B vdw Kidayy fhytdhkllh (G) kwWk cah kydjilahffy toyNa

,izffgglLssJ. fkgad kJss njhL rhtad eiyia (Position) msTNfhy %yk mstlyhk. rkdrRwW fkgad Kidfsd FWfNf xU nyfyhQr kdfyKk rhtAk (K) ,izffgglLssd.

kl;lh; rkdrRwW

fkgad kJ njhLrhtia efhjj fhytdh kllhy Ro tyffk VwgLkhW nraa NtzLk. njhL rhtad eiyia J vd vLjJf nfhsNthk. AJ kwWk JB vDk esqfs KiwNa tl]Nlhd rkdr Rwwd kdjilahffifs R kwWk S fF gjyhf mikeJssJ.

$$\frac{P}{Q}=\frac{R}{S}=\frac{r.AJ}{r.JB}$$

,qF r vdgJ xuyF esjjwfhd kdjil MFk.

$$\frac{P}{Q}=\frac{AJ}{JB}=\frac{l_1}{l_2}$$

$$P=Q\frac{l_1}{l_2}$$

rkdrRwW fkgahdJ jhku glilfsd kJ gww itjjUggjhy KOikaww ,izggd fhuzkhf› ,izggy kfrrwa msT kdjil mjfhjjUfff $Lk. ,ej kdjilahffifs Kid kdjilfs (End resistance) vdwioffggLk. ,ggioia eff P kwWk Q it ,lggh khwwk nraJ Nrhjid kzLk xUKiw nraagglL kwnwhU mstl vLffgglL Pd ruhrh kjgG fzlwaggLfwJ.

P vDk fkgrRus nraaggll nghUsd kdjil vziz fzffl mjd Muk *a* kwWk esk *l* Mfait mstlggLfdwd. jd kdjil myyJ kdjil vz ρ gdtUk njhlhgdhy ngwggLfwJ.

kdjil $r=\frac{l}{A}$

Nkwfzl rkdghlil khwwd mikff.

$$\rho = \text{kd jil} \times \frac{A}{l}$$

vdgJ njhahj kdjil vdy rkdghL gdtUkhW mikAk.

$$r=P\frac{pa^2}{l}$$

kd;dOj;jkhdp:

kddOjjkhdahdJ kddOjj NtWghL› kdNdhllk kwWk kdjilfis Jyyakhf mstl gadgLfwJ. ,jy gjJ kllh esKss ruhd Nkqfsd myyJ fhd]lhzld fkgahdJ 1 kllh esKss ,izahd thirfshf ellgglL kuggyifay nghUjjggllssJ. fkgad ,izffgglhj A kwWk B Kidfs xNu gffjjwF nfhzL tugglL ,izgGjjUFfSld jhkuggllilfsy nghUjjgglLssd. xU kllh msT Nfhy fkgfF ,izahf nghUjjgglLssJ.

kddOjjkhdad jjJtk fhllgglLssJ. fkg CD toNa xU eiyahd kdNdhllk VwgLjjggLfwJ.

kdfyjnjhFgG› rht kwWk kddOjjkhd fkg Mfait njhlhizggy ,izffgglL Kjdikr Rwwhf mikfwJ. kddafF tir ε nfhzl kdfyjjd NehkdKid C GssAlDk› vjh kdKid fhythdh kllh kwWk cah kdjil toahf njhLrhtAlDk ,izffgglLssd. ,J Jizr Rwwhf mikfwJ.

njhL rhtcjtAld J vdw Gssay ,izgG VwgLjjggLfwJ. CJgFjad FWfNf css kddOjj NtWghL› kdfyjjd kddafF tir ε fF rkkhdhy fhythdhkllh toNa vttj kdNdhllKk ghakhy mJ Ro tyffjij fhlLk. vdNt CJ vdgJ rkdnra esk vdW mioffggLk. CJ fF FWfNf css kddOjj NtWghL *Irl*. ,qF *r* vdgJ xuyF esjjwfhd kdjil MFk.

vdNt $\varepsilon = Irl$

,qF *I* kwWk r khwyfs vdgjhy ε µ *l* kdfyjjd kddafF tir rkdnra esjjwF Nehjjftiy mikAk

kddOjjkhdia gadgLjjj ,U kdfyqfsd kddafF tirfis xggLjy

,U kdfyqfsd kddafF tirfis xggl› cssthW kdRwW ,izgG VwgLjjggLfwJ. kddOjjkhd fkg CD MdJ kdfyjnjhFgG Bt kwWk rht K cld njhlhizggy ,izffgglLssJ. ,J Kjdikr RwW MFk. fkgad C Kid DPDT rhtay css (Double Pole Double Throw) M Kiday ,izffgglLssJ. N KidahdJ fhythdh kllh (G), cah kdjilahff (HR) toahf njhL rhtAld ,izffgglLssJ. kddafF tirfs xggl NtzLba ,U kdfyqfs ε_1 kwWk ε_2 KiwNa DPDT ,y css M_1, N_1 kwWk M_2, N_2 KidfSld ,izffgglLssd. kdfyjnjhFggd (Bt) Neh kdKid kwWk ε_1, ε_2 Mfa kdfyqfsd Neh kdKidfs Mfait kddOjjkhd fkgay css C KidaNyNa ,izffggl NtzLk.

DPDT rhtia *M₁, N₁* Kidfsy mOjJk NghJ ε_1 kdfyk JizrRwwy ,izffggLfwJ. ,gNghJ njhL rhtia efhjj fhytdh kllhy Ro tyffk ngwgglL rkdnra esk l_1 mstlggLfwJ. gddh ,uzlhtJ kdfyk ε_2 kdRwwy ,izffgglL rkdnra esk l_2 fzlwaggLfwJ. rvdgJ kddOjjkhd $kgad XuyF esjjwfhd kdjil vdTk *I* vdgJ fkg toNa ghAk kdNdhllkhfTk nfhzlhy

$$\varepsilon_1 = Irl_1$$
$$\varepsilon_2 = Irl_2$$

rkdghL

$$\frac{e_1}{e_2} = \frac{l_1}{l_2}$$

kddOjj khdia gadgLjj kdfyjjd mfkdjilia mstLjy

kdfyjjd mfkdjilia mstl› ,izgGfs NkwnfhssggLfdwd. kdfyjnjhFgG Bt ,d NehkdKid kddOjjkhd fkgad C KidTlDk vjhkdKid rht K_1 toahf D KidAlDk ,izffgglld. ,JNt Kjdikr Rwwhf mikfwJ.

mfkdjil fhzNtzba kdfyk ε ,d NehkdKid kddOjjkhdf fkgad C KidAld ,izffggLfwJ. kdfyjjd vjhkdKidahdJ fhytdhkllh› cahkdjilahff toahf njhLrht J cld ,izffggLfwJ. kdfyk ε d

FWfNf xU kjdjilgnglb R kwWk K_2 jwej epiyapy rkdnra Gsspj f z lwpaggLL rkdnra esk CJ = l_1 mstplggLfpwJ.

kjdfykhdJ jwej Rwwpy miktjhy mjd kjddpafF tpir

$$\varepsilon \propto l_1$$

kjdjilgnglb R y xU jFej kjdjilahffp (10Ω vd ,UfflLk) NjhenjLffggll K_2 rhtp %lggLfpwJ. r vdgJ kjdfyjjpd mf kjdjil vdf. kjdjil R kwWk kjdfyk topNa kjdNdhllk I MdJ ,ej kjddOjj NtWghL kjddOjjkhdpffkgpff FWfNf css kjddOjj NtWghllhy rkdnraaggLfpwJ. ,ej epsjij l_2 vdf. vdNt

$$I = \frac{e}{R+r}$$

R d FWfNf css kjddOjj NtWghL

$$V = \frac{eR}{R+r}$$

$$\frac{eR}{R+r} \mu l_2$$

$$\frac{R+r}{R} = \frac{l_1}{l_2}$$

$$1 + \frac{r}{R} = \frac{l_1}{l_2};$$

$$r = R\left(\frac{l_1}{l_2} - 1\right)$$

$$\therefore r = R\left(\frac{l_1 - l_2}{l_2}\right)$$

R, l_1 kwWk l_2 kjpgGfis gujpapl kjdfyjjpd mfkjdjil f z lwpaggLfpwJ. ,rNrhjidahdJ R ,d nttNtW kjpgGfSfF kzLk nraaggLfpwJ. Nrhjidapd KbTfspdgb kjdfyjjpd mfkjdjil khwypahf mikahky kjdfyjjpd FWfNfAss Gw kjdjil kjpgG mjpfhpfFk NghJ mjpfhpggij fhzyhk.

kjdpNdhl;ljpjpd; ntgg tpisT

xU kjdjilahffpapd topahf kjdNdhllk ghAk NghJ› kjdjilahffpfF mspffggLk kjddhwwypy rpwpjsT ntgg Mwwyhf khwwgglL tzhfpwJ.

kjdpNdhl;ljpjpd; ,ej ntggtpisNt [{y; ntgg tpisT vdggLk;

kjdNdhllk vtthW ntgg Mwwiy VwgLjJfpwNjh mNjNghy ntgg Mwwiy jFej Kiwapy gadgLjjp kjddpafF tpiria (kjd Mwwy) ngw KbAk. ,JNt ntgg kjd tpisT vdggLk.

[lypd; tpjp

xU fljjpapd FWfNf css *V* vDk kjddOjj NtWghlbdhy *I* vdw kjdNdhllk *t* Neujpwf ghafpwwJ vdpy› kjdfyjnjhFggpdhy nraaggll Ntiy myyJ gadgLjjggLk kjddOjj Mwwy

$$W = VIt$$

Gw tpisTfs VJk ,yiynadpy› ,ej Mwwy fljjpia ntggggLjj gadgLk. ,jd %yk cUthFk ntgg Mwwy (H) MdJ

H = VIt

fljjpapy kpdjil R ,Uejhy›

$H = I^2Rt$

,ej njhlhG [{y vdgtuhy Nrhjid Kiwapy rhpghhffggllJ. vdNt ,J [{y ntgg tpjp vdggLk. [{ypd tpjpggb› xU kpdRwwpy kpdNdhllk ghatjhy cUthffggLk ntggkhdJ

1. kpdNdhlljjpd ,UkbfF Nehjjftpyk
2. kpdRwwpd kpdjilfF Nehjjftpyk
3. kpdNdhllk ghAk Neujjpwf Nehjjftpyk mikAk

[{y; ntgg tpjpapd; gadghLfs;

1. kpd; #Nlwwpfs;

kpd ,]jhpnglb› kpd #Nlwwp› nuhlbRLk kpdfUtp Kjypad kpdNdhlljjpd ntgg tpisit gadgLjJk tlL cgNahfr rhjdqfshFk. ,ej rhjdqfspy #NlwWk fkgpahdJ epffy kwWk FNuhkpajjpd cNyhff fyitahd epfNuhkpdhy MdJ. epfNuhkpd kpdjil vz kpf mjpfk. NkYk ,jid Mf]pNdwwk milahkNy kpf mjpf ntggepiyfF ntggggLjj KbAk.

kpd; cUfpf; fkgpfs;

mjpfkhd msT kpdNdhllk kpdrhjdqfs topahf ghAkNghJ NjhdWk ntggjjpdhy mit ghjpffgglhky ,Uff njhlhpizggpy kpd cUfpfs fhlbAssthW ,izffggLfpdwd. kpd cUfpf fkgpfs vdgJ kpff Fiwej esKss Fiwthd cUFepiy nfhzl nghUshyhdit. kpdNdhlljjpd msT Fwpggpll kjpgigtpl mjpfhpfFk NghJ ,it cUfp kpd Rwiw jpwej RwwhfFk. 15A fF Fiwthf kpdNdhllk nryYk kpdRwWfspy fhhak (Lead) kwWk ntssajjpdhy (Tin) Md cNyhfffyit kpd cUF ,ioahf gadgLjjggLfpwJ. 15A fF mjpfkhd kpdNdhllk nryYk kpdRwWfspy kwWk jhkpuffkgpfs kpd cUF ,ioahf gadgLjjggLfpwJ.

,ej kpd cUF ,ioapy css FiwghL vddntdwhy kpdNdhllk Fwpggpll msit

tpl mjpfhpfFk NghJ cUfp vhpeJ tpLtjhy mjid khww Ntzba mtrpak VwgLfpwJ.

jwNghJ ekJ tLfspy kpd cUfpfSfF gjpyhf kpdRwW Jzbggdfs (Trippers) gadgLfpdwd. jtwhd kpd ,izgGfs myyJ msTfF mjpfkhd kpdNdhllk kpdRwwpy ghAkNghJ kpd Jzbgghdfspd rhtp kpd Rwiw jpweJtpLk. gpddh kpdRwwpd gOij effpaTld› ehk kpd Jzbgghdpd rhtpia %b tplyhk.

kpd; ciyfs;

ciyfs v/F› rpypffhd fhhigL› Fthhl]› Nfypak Mhrpidl Nghdw njhopy Elg Kffpajtk thaej gy nghUlfis cUthff gadgLjjggLfpdwd. 1500°C ntggepiy tiu cUthff khypgbdk - epffy fkgp Rwwggll rpypffh Foha gadgLfpdwJ. fhhgd tpy ciyfs (Carbon are furnaces) Rkhh 3000°C ntggepiy tiu cUthff gadgLfpdwd.

kpd; tpsfFfs;

kd tsfFfsy lqf]ld ,iofs (cUFepiy 3380°C) fzzhb FLitfsy itffgglL kdNdhllk %yk k cah ntggepiyfF #NlwwggLfdwd. kd tsfFfsy (Incandescent lamp) 5% klLNk kd Mwwy xsahf khwwggLfwJ. kjKss Mwwy ntggkhf tzhfwJ. kddwff tsfFfs (Discharge lamp), kd gwwitjjy (ntybq)› kd ty Nghdwit kdNdhlljjd ntggtpisit gadgLjJfdwd.

ntgg kd; tpisT:
ntggkd tpisT vdgJ ntggepiy NtWghlil kddOjj NtWghlhf khwWk epfoT MFk. ntggkd rhjdjjd ,U gffqfspYk css ntggepiy NtWghlbd fhuzkhf kddOjj NtWghL NjhdWfwJ. mNjNghy kddOjj NtWghlil ,gnghUlfsy VwgLjjpdhy› ntgge piy NtWghL NjhdWk.

rngf; tpisT
xU %ba Rwwy ,U nttNtW cNyhfqfspd ,U rejpgGfis nttNtW ntggepiyfsy itfFkNghJ kddOjj NtWghL (kddpafF tpir) NjhdWtij rngf fzlwejhh. ,k kddpafF tpirapdhy VwgLk kdNdhlljij ntggkdNdhllk vdwioffyhk. ,U cNyhfqfs ,izjJ rejpgGfis VwgLjJtJ ntgg kddpulil (Thermocouple) vdggLk.

ntgg kwWk Fsph rejpfis ,lkhwwk nrajhy kdNdhlljjpd jpirAk khWk. vdNt ,ej tpisT xU ks tpisT MFk.

ntgg kddpulilapy NjhdWk kddpafF tpirapd vzkjpgG (1) kddpulilapy ,lkngWk cNyhfqfspd jdik kwWk (2) rejpfspd ntgge piy NtWghL Mfpatwiw nghWjjJ.

rngf; tpistpd; gadghLfs;

1. rngf tpisthdJ ntgg kddpawwpfsy gadgLfwJ (rngf kddpaww). ,ej ntgg kddpawwpfs› kd cwgjjp epiyaqfsy tzhFk ntgg Mwwiy kddhwwyhf khWfpdwd.

2. jhdpaqfp thfdqfsy vhpnghUs gaDW jpwid mjpfhpff gadgLk jhdpaqfp ntgg kddpawwpfsy gadgLjjggLfwJ.

3. ntgg kddpulil kwWk ntgg kddpulil mLfFfsy gadgLjjggLk ngUlfSffpilNa css ntgge piy NtWghlil mstpl rngf tpisT gadgLfwJ.

ngybah; tpisT

ntgg kddpulilAld $ba kd Rwwy kdNdhlljij nrYjJkNghJ› xU rejpapy ntggk ntspggLjYk kwnwhU rejpapy ntggk clfthjYk eilngWk. ,ttpisT ngybah tpisT vdggLk. ,jid ngybah 1834 y fzlwejhh.

Cu-Fe ntgg kddpulilapy A kwWk B Gsspy rkntgge piyapy cssd. kdfy mLffpyUeJ kdNdhllkhdJ ntggkddpulil topNa ghafwJ. A rejpapy kdNdhllk jhkpujjpyUeJ ,UkgwF ghafwJ. mqF ntggk clftuggLL rejp A Fsphtilfwj. rejp B y kdNdhllk ,Uggpy UeJ jhkpujjwF ghatjhy mqF ntggk ntspggLL rejp B ntggkilfwJ. kdNdhlljjpd jpiria khwwpdhy› A

rejp ntggilAk› B rejp Fsphtilak. vdNt ngybah tpisT xU ks tpisT MFk.

jhk]d; tpisT
xU fljjpad ,UGsspfs nttNtW ntggepiyfspy cssNghJ› ,ej Gsspfspy vyfluhd mlhjjp NtWgLtjhy ,ttpU GsspfSffpilNa kpddOjj NtWghL cUthffggLk vdgij jhk]d epg&gjjhh. jhk]d tpisTk kstpisT MFk.

C vDk ikagGsspay ntggggLjjggLk AB vDk jhkpuj jzL topNa kpdNdhllk ghafpwJ vdpy› C vdw Gsspcah kpddOjjjjpy mikAk. ,jdy AC gFjpapy ntggk clfthjYk CB
gFjpapy ntggk ntspggLjYk eilngWk.

vdNt kpdNdhll ghatpd fhuzkhf kpdNdhlljjpd jpirapy ntggg ghpkhwwk eilngWk. ,J NehfFwp jhk]d tpisT vdggLk. ,J NehfFwp jhk]d tpisT vdggLk. ,J Nghdw tpisT ntss› Jjjehfk kwWk fhlkpak Nghdw cNyhfqfspYk eilngWk.

jhkpuj jzLfF gjpyhf ,UkGjjzbid gadgLjJkNghJ› CA gFjpapy ntggk ntspggLjJjYk BC gFjpapy ntgg clfthjYk eilngWk. ,qF kpdNdhll ghatpdhy kpdNdhlljjpd jpirfF vjph jpirapy ntgg ghpkhwwk eilngWk. ,J vjphfFwp jhk]d tpisT vdggLk. ,J Nghdw tpisT gpshlbdk effy› Nfhghyl kwWk ghjurk Nghdw cNyhfqfspYk eilngWk.

myF 7
miy xspapay; (WAVE OPTICS)

xspiaggwwpa nfhspiffs; (Theories of Light)

xsp vdgJ xUtifahd MwwyhFk. ,tthwwy Xhpljjpy pUeJ› kwNwhh ,ljjpwFg guTfpwJ. mwptpay mwpQhfshy Kditffggll xspiag gwwpa gyNtW nfhspiffs xspapd jdikiag gwwp klLk $whky xspguTk Kiw kwWk xspapdhy VwgLk epfoTfisg gwwpAk tpsfFfpdwd.

Ez;Jfs; nfhspif (Corpuscular theory)

xspisggwwp EzJfs nfhsifia rh Irf epAlld (Sir Isaac Newton) (16720 nfhLjjhh. ,jwF KdNg› nl]fhhl] (Descartes) (1637) xsp vjpnuhspgG kwWk xsptpyfiy tpsfFtjwFfhf ,fnfhsifiag ghpeJiujjhh. ,fnfhsifapdgb xsp kpfrrpwpa› epiwaww (Gwffzpjjff rpwpa epiw) kwWk KO klrpAWk Jfsfshf ckpoggLfpdwJ. ,twWfF EzJfsfs (corpuscles) vdW ngah. EzJfsfs kpfrrpwpait. vdNt› xsp%yk ezl fhyjjpwF xspia ckpoejhYk› mjd epiwapy Fwpggpljjff khwwk VJk VwglhJ.

EzJfsfs kpfNtfkhfr nrytjhy› mit Gtpahgg tpirapdhy vttpjghjpgigAk milahJ. NkYk› xNu xsptpyfy vz nfhzl ruhd Clfjjpy EzJfsfspd ghij xU NehNfhlhFk. ,ej EzJfsfspd ,aff MwwNy xspapd MwwyhFk. ,ej EzJfsfs tpopjjpiuapd kJ NkhJtjhy ghhit VwgLfpdwJ. nttNtW msTfs nfhzl EzJfsfs nttNtW tzzqfisj NjhwWtpffpdwd. EzJfsfs ,uzL Clfqfisg gphpfFk jsjjpid milAk NghJ› mit <hffgglyhk myyJ tpyffgglyhk. Clfjjpdhy EzJfsfs tpyffgglhy xsp vjpnuhspgGk› <hffgglhy xsptpyfYk VwgLfpdwJ.

xspahdJ mlhFiw Clfjjpy NtfkhfTk› mlhkpF Clfjjpy nkJthfTk nrytjwfhd fhuzjij ,fnfhsifahy tpsffKbatpyiy. NkYk› FWfflL tpisT› tpspkG tpisT kwWk jstpisT Nghdw epfoTfisAk ,fnfhsifahy tpsffKbatpyiy.

miyf;nfhs;if (wave Theory)

Clfjjpd topahf xsp guTtij tpsfFtjwfhff fph]bad i`nfd] (Christian Huygens) (1678) miyfnfhsifia Kdnkhopejhh. ,thpd nfhsifapdgb› xsp vdgJ xsp%yjjpdhy VwgLk xU khWghlhFk. ,kkhWghL ntspKOtJk epukgpAss Xh Clfjjpd topNa ,aejpu miyahd nelliy tbtpy guTfpwJ vdTk› ,aejpu miy guTtjwF Clfk mtrpak. vdNt› <jh (ether) vdw Clfk ntsp KOtJk gutpAssJ vdTk Af;fjJfnfhzlhh. xsp vjpnuhspgG› xstpyfy› FWfflL tpisT kwWk tpspkG tpisT Nghdw xspapd tpisTfis miyfnfhsif edF tpsffpaJ.

gpdG› ntspKOtJk gutpAss <jh Clfjijggwwp ,th nfhsif jtW vdW e%gpffggllJ. vdNt› ntwwpljjpd topNa xsp vtthW guTfpdwJ vdgijAk ,fnfhsifapdhy tpsff Kbatpyiy. NkYk› xspapd jstpisitAk ,fnfhsifapdhy tpsff Kbatpyiy. Vnddpy› jstpisT vdgJ FWffiyfspd gzghFk.

kpd;fhej miyf;nfhs;if (Electromagnetic wave theory)

xsp FWffiy tbtpy guTk kpdfhej Mwwiy RkeJ nryYk kpdfhej miy vdW Nkf]nty (Maxwell) (1864) epgpjjhh. NkYk› kpdfhej miy guTtjwF vttpj ClfKk Njitapyiy vdWk ,tuhy epgpjJf fhll KbejJ. xspapd midjj epfoTfisAk ,fnfhsif ntwwpfukhf epgpjjJ.

,Ugg pDk› ,fnfhsifapdhy xsp kwWk gUgnghUSfF ,ilNa VwgLk ,iltpidia mjhtJ› xspkpd tpisT (Photoelectric effect) kwWk fhkld tpisT (Compton effect) Nghdwtwiw tpsff Kbatpyiy.

Fthz;lk; nfhs;if (Quantum theory)

Myghl ld]Bd (Albert Einstein) (1905), Nkf] gpshq (1900)fpd fUjJfis cWjpggLjJk tpjkhf› xspkpd tpisit tpsffpdhh. xspkpd tpistpdgb› xspahdJ /Nghllhd tbtpy gUgnghUspd kJ Nkhjp› gUgnghUspypUeJ vyfluhdfis ckpor nrafpwJ. /Ngllhd vdgJ jdpjjdp Mwwy rpggqfshFk. xtnthU /NghllhDk ngwWss Mwwy E MFk. MjhtJ›

$$E = hv$$

,qF› *h* vdgJ gpshq khwpypahFk. *(Plank's constant) (h = 6.625 × 10^{-34} Js)* kwWk vdgJ kpdfhej miyapd mjhntzizf Fwpffpwj.

miyggzG kwWk Jfs gzG ,uzL gzGfisAk xUqNf ngwWss xspapd ,ggzgpwF› ,ulilggzG vdW ngah. xsp guTkNghJ miyahfTk› gUgnghUSld ,iltpid GhpAkNghJ JfshfTk nraygLfpdwJ vdW KbT nraaggLfpwJ.

xspapd; miyggzG (Wave nature of light)

xsp FWffiy tbtpy css kpdfhej miyahFk. FWfflL tpisT kwWk tpspkG tpisT njhlhghd Nrhjidfspy ,UeJ xspapd miyggzG ekfFf fhllggllJ. xspapd FWffiyggzig tpsfFk epfoT jstpisthFk. midjJ kpdfhej miyfisg NghdNw xspAk ntwwpljjpd topNa guTk.

miy xspapay; (Wave optics)

xsp vjpuhspgG kwWk xsp tpyfy epfoTfis miy xspapaypd mbggilapyjhd tpsff KbAk. xsp miytbtpy gutpdhYk xspguTk jpir xspffjpiuf nfhzLjhd Fwpggplggl fpwJ.

rydkww jz zhggugpgd kJ fyxdwpidg NghLkNghJ› mffy tpOej gFjpiar Rwwp tlltbt rpwwiyfs xsp vjpuhspgG kwWk xsp tpyfy epfoTfis miy xspapaypd mbggilapyjhd tpsff KbAk. xsp miytbtpy gutpdhYk xspguTk jpir xspffjpiuf nfhzLjhd Fwpggplggl fpwJ.

xNu rydkww jz zhggugpgd kJ fy xdwpidg NghLkNghJ› mffy tpOej gFjpiar Rwwp tlltbt rpwwiyfs guTk. ,eepforrp miyguTtjwF Xh rpwej cjhuzkhFk. rpwwiy xU Fwpggpll Gsspiaf fleJ nryYk NghJ› mgGsspapy css eh %yf$Wfs myyJ Jfsfs NkYk fOkhf ,aqFk (myyJ) miyTWk. xU ikagGsspapypUeJ rknjhiytpy css rpwwiyapd midjJf JfsfSk xNu flljjpy mjphtilAk miyKfgigg nfhzbUfFk xNu epiyapy myyJ xNu flljjpy mjphtilAk Gsspfis ,izfFk KdGw ciwfF miyKfgG vdW ngah. miyguty vdgJ› miyKfgG guTtijNa Fwpffpwf. miyKfgG vgNghJk miyguTk jpirfF nrqFjjhfNt ,UfFk. xspffjphdjpir miyguTk jpirapNyNa ,Uejhy› miyKfgG› vgNghJk xspffjphd jpirfFr nrqFjjhf fhllggllLssJ Nghy ,UfFk.

xU Gsspapy cwWNehffggLk miyKfggpd tbtk xsp %yjjpd tbtjijAk› xsp %yk mikeJss njhiyitAk rhheJssJ. tukGfFlgll njhiytpy mikeJss xU Gsspxsp %yk vgnghOJk Nfhsf miyKfgigNa jUfpwJ. tukGfFlgll njhiytpy mikeJss ellggll (myyJ) NfhlL xsp%yk› cUis tbt miyKfgigj jUfpwJ. <hpyyhj njhiytpy mikeJss vej Xh xsp %yjjpdhYk NjhdWtJ rkjs miyKfgGfs.

i`nfd]; jjJtk; (Huygens' Principle)

i`nfd] jjJtk mbggilapy xU tbtpay fllikgghFk. *t = 0* vdw Neujjpy miyKfggpd tbtk ekfFj njhejhy› vej xU Neujjpyk css miymiyKfggpd tbtjij i`nfd] jjJtjijg gadgLjjp ehk fzlwpayhk. i`nfd] jjJtjjpdgb› miyKfggpYss xtnthU Gsspak ,uzlhk epiy miyfFlbfis cUthfFk xsp %ykhfr nraygLk. ,gGsspfspypUeJ ntsptUk ,uzlhkepiy miyfFlbfs› miyapd Ntfjjpy› Clfjjpd midjJj jpirfspYk guTk. ,ej ,uzlhk epiy miyFlbfSfF tiuaggLk nghJthd njhLNfhL myyJ ,uzlhk epiy miyfFlbfspd KdGw ciw› mLjJ VwgLk Gjpa miyKfgigf nfhLfFk. vdNt› i`nfd] jjJtk miyKfggpd gutiy tpsfFfpwJ. Nfhsf kwWk rkjs miyKfgGfspd gutiy i`nfd] jjJtjjpd %yk tpthffyhk. *t = 0* vdw Neujjpy css miyKfgig› *AB* vdf. i`nfd] jjJtjjpdgb *AB* miyKfggpd xtnthU Gsspak› miyapd Ntfjjpy (xspapd Ntfk c - ,y) nryYk ,uzlhk epiy miyfFlbfis cUthfFk xsp%ykhfr nraygLk *t* fhyk fopjJ miyKfggpd Gjpa epiyia mwptjwF AB kJss P,Q,R... vdw Gsspfis ikakhff nfhzL *ct* I Mukhffnfhz L tllqfs tiuaNtzLk. ,rrpWtllqfspd KdGw ciw myyJ njhLNfhL *A'B'* MdJ *t* Neujjpy VwgLk Gjpa miyKfgghFk. Fwpggpll njhiytpYss Gsspxsp %yjjhy VwgLk ,gGjpa miyKfgG A 'B' xU Nfhsf miyKfgghf ,UfFk. ,J fhllggllLssJ. xsp%yk kpf ezl J}ujjpy (<hpyyhj njhiytpy) ,Uejhy rkjs miyKfgghf ,UfFk.

miyguTtij tpsfFk i`nfd] fllikggpy xU FiwghL cssJ. Nkwfzl fllikggpy NjhdWk gpdmiy (Back wave) vtthW kiwfpdwJ vdgij

,fnfhsif tsfftyiy. kdfhej miyfnfhsifad mbggilay gd miyfsd guty ,ayghfNt xJffjjssggLfdwd. ,UejNghjYk› i`nfd] fllikgG miyKfgG xdwd gutiy tiugl tbtyedF tsfFfwJ.

i`nfd]; jjJtjjd; mbggilay; vjnuhsgG tjjfis e&gjjy; (Proof for Laws of reflection using Huygens' Principle)

XY vdw rkjsf fzzhbad vjnuhsgGg guggd kJ fhlbAssthW ,iz xsffwiwfs tOfdwd vdf fUJf. gLk rkjs miyKfgG AB kwWk vjnuhsgG miyKfgG A'B' ,ttuzL miyKfgGfSk xNu Clfjjy cssd. ,ej miyKfgGfs gLfjhfs M,M kwWk vjnuhsgGf fjhfs L', M' Mfatwwwfr nrqFjjhf cssd. gLk miyKfggYss A Gss› vjnuhsgGg gugigj njhLk Neujjy› B Gss BB' njhiyT gazk nraJ› vjnuhsgGg guggYss B' Gssia milfwJ.

B Gss vjnuhsgGg guggYss B' Gssia njhLk mej Neu ,ilntsay A Gss A' I milfwJ. miyKfggYss midjJg GssfSfFk ,J nghUeJk. vdNt› A'B' vdw rkjs vjnuhsgG miyKfgG filfFk. xsffjhfs L kwWk M ,uzLk vjnuhsgGg guggy tOk Gssfsy N kwWk N' vdw ,uzL nrqFjJfNfhLfs tiuaggLfdwd. vjnuhsgGk ,Nj Clfjjy eilngWtjhy vjnuhsgGfF KdGk kwWk vjnuhsgGfFg gdGk xsad

> jirNtfjjy vttj khwwKk VwglhJ. xs A tyUeJ A' tu vLjJfnfhsSk NeuKk B ayUeJ B' tu vLjJfnfhsSk NeuKk rkk. ,jdfhuzkhfj njhiyTfs AA' kwWk BB' ,uzLk xdWfnfhdW rkk (AA' = BB')

1. gLfjhfs› vjnuhsgGffjhfs› vjnuhsgGg gugG kwWk nrqFjJfNfhL midjJk xNu jsjjy cssd.
2. gLNfhzk›

$$Đi = ĐNAL = 90^\circ - Đ\ NAB = Đ\ BAB'$$

vjnuhsgGf Nfhzk›

$$Đr = ĐN'B'M' = 90^\circ - ĐN'B'A' = ĐA'B'A$$

nrqNfhz KfNfhzqfs ΔABB' kwWk ΔB'A'A ,uzbYk nrqNfhzqfs ĐB kwWk ĐA' rkk. (ĐB kwWk ĐA' = 90°); AA' kwWk BB' ,uzL gffqfSk rkk (AA' = BB') NkYk› gffk AB' ,uzL nrqNfhz KfNfhzqfSfFk nghJthdJ. vdNt› ,ttuzL KfNfhzqfSk xgG KfNfhzqfshFk (Congruent). xgG KfNfhzqfSfFf Nfhzqfs Đ BAB' kwWk Đ A'B'A Mfait xdWfnfhdW rkkhFk. vdNt›

$$i = r$$

gLNfhzk› vjnuhsgGf Nfhzjjwfr rkkhFk. vdNt› vjnuhsgG tjjfs e&gffgglld.

i`nfd]; jjJtjjd; mbggilay; xstyfy; tjjfis e&gjjy; (Proof for Laws of refraction using Huygens' Principle)

xsGFk jdik nfhzl fzzhbg gugG XY d kJ› fhlbAssthW ,iz xsffwiwfs tOfdwd vdf fUJf. gLk rkjs miyKfgG AB mlhFiw Clfk (1) Yk› xstyF miyKfgG› gugG XY d kJ› fhlbAssthW ,iz

xsffwiwfs tOfdwd vdf fUJf. gLk rkjs miyKfgG AB mlhFiw Clfk (I) Yk› xstyF miyKfgG› mlhkF Clfk (2) Yk cssd. ,ttuzL miyKfgGfSk gLfjh L, M kwWk tyF L', M' MfatwwwFr A Gss xstyF gugigjnjhLk mej Neujjy› B Gss BB' njhiyitf fleJ xstyF guggd B'

dw Gssiaj njhLfwJ. B Gss xstyF guggd B Gssiaj njhLk Neujjy A Gss kwNwhh Clfjjy A' njhiyit flffwJ. miyKfggYss midjJg GssfSfFk ,J nghUeJk. vdNt A'B' vdw rkjs xstyF miyKfgG filfFk. xstyF guggy L kwWk M fjhfs gLk Gssay N kwWk N' vdw ,uzL nrqFjJf NfhLfs fUjggLfdwd. ,qF mlh Fiw Clfjjy (1) ,UeJ› mlhkF ClfjjwF (2) xstyfy VwgLtjhy› xstyfYfF KdG xsad jirNtfk v_1 kwWk xstyfYfFg gdG xsad jirNtfk v_2 MFk. ,qF v_1 MdJ v_2 I tl mjfk. Mdhy› xsffjhfs B ayUeJ B' GssfFr nryy vLjJfnfhsSk NeuKk› A tyUeJ A' GssfFr nryy vLjJfnfhsSk NeuKk rkk.

$$t = \frac{BB'}{v_1} = \frac{AA'}{v_2} \quad (\text{myyJ}) \quad \frac{BB'}{AA'} = \frac{v_1}{v_2}$$

1. gLfjhfs› tyFfjhfs› xstyF gugG XY kwWk nrqFjJfNfhLfs midjJk xNu jsjjy mikfdwd.
2. gLNfhzk›
   $i = \angle NAL = 90^\circ - \angle NAB = \angle BAB'$
   tyFNfhzk›
   $r = \angle N'B'M' = 90^\circ - \angle N'B'A = \angle A'B'A$

   nrqNfhz KfNfhzqfs $\Delta ABB'$ kwWk $\Delta AA'B$ - ,uzbYkUeJ

   $$\frac{\sin i}{\sin r} = \frac{BB'/AB'}{AA'/AB'} = \frac{BB'}{AA'} = \frac{v_1}{v_2} = \frac{v_1}{v_2} \cdot \frac{c}{c} = \frac{c/v_2}{c/v_1}$$

,qF c vdgJ› ntwwlljjy xsad NtfkhFk. tfjk c/v xU khwyahFk. ,kkhwyfF Clfjjd xstyfy vz vdW ngah. Kjy Clfjjd (1) xstyfy vz $c/v_1 = n_1$ kwWk ,uzlhtJ Clfjjd (2) xstyfy vz $c/v_2 = n_2$ MFk.
tfj tbty

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

ngUffy tbty
   $n_1 \sin i = n_2 \sin r$

vdNt› xstyfy tjfs e&gffgglld. ,NjKiwajy› miyKfgG mlhkF Clfjjy ,UeJ› mlhFiw ClfjjwF tUkNghJk xstyfy tjfis e&gff KbAk.

xsad Ntfk xstyfy vzzwF vjhjjftYk miyesjjwF NehjjftYk ($v \propto \lambda$) cssjhy›

$$\frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

Fwggll mjhntz nfhzl xs nttNtW Clfqfsd toahfr nrdwhYk mjd mjhntz khwwkilahJ. Mdhy› miyesk kILNk mtTlfjjy xsad NtfjjwF Vwg khwwkilAk.

FWf;fl;L tpisT (Interference)

,uzL xsp miyfs xdwpd kJ kwnwhdW NkwnghUeJ tjhy rpy Gsspfspy xsprnrwpT mjpfhpfFk› NtWrpy Gsspfspy xsprnrwpT FiwAk epfoTfF xsapd FWfflL tpisT vdW ngah. NkwnghUejy vdgJ xsp miyfspd $Ljiyf Fwpffpwf. ,aejpu miyfspd NkwnghUeJjpiyggwwp ,uzL miyfs xNu Neujjpy Clfjjpyss Jfspd topNa nryYkNghJ njhFgad ,lngahrrpahdJ xtnthU njhFgad ,lngahrrpahdJ xtnthU miyapdhYk Jfspd kJ VwgLjJk jdpjjdp ,lngahrrpfspd ntflh $LjYfFr rkk. NkwnghUeJk miyfSfF ,ilNa css flNtWghlilg nghUjJ› njhFgad ,lngahrr ngUkkhfNth myyJ rpWkkhfNth ,UfFk.

,ffUjJfs xspfFk nghUeJk. S_1 kwWk S_2 vdw ,uzL xsp %yqfspypUeJ tUk xsp miyfisf fUJf. mit Pvdw Gsspapy rejpffpdwd.

t Neujjpy S_1 xsp %yjjpy ,UeJ PGsspia milAk miy›

$$y_1 = a_1 \sin wt$$

t Neujjpy S_2 xsp%yjjpy ,UeJ PGsspia milAk miy›

$$y_2 = a_2 \sin (wt + f)$$

,ttpuzL miyfSk› nttNtW trRfisAk a_1 kwWk a_2 xNu Nfhz mjphntzizAk w kwWk f vdw flNtWghlilAk ngwWssd. ,ttpuzL miyfspdhy Vwgll njhFgad ,lngahrrp

$$y = y_1 + y_2 = a_1 \sin wt + a_2 \sin (wt + f)$$

KfNfhz tpay KwnwhUikfisg gadgLjjp ,rrkdghlilj jhT nraAkNghJ› gpdtUk rkdghL fpilfFk.

$$y = A \sin (wt + \theta)$$

,qF $A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2 \cos f}$

$$q = \tan^{-1} \frac{a_2 \sin f}{a_1 + a_2 \cos f}$$

$f = 0, \pm 2p, \pm 2p....,$ vdw epgejidfspy njhFgad trR ngUkkhFk›

$$A_{max} = \sqrt{(a_1 + a_2)^2}$$

$f = \pm p, \pm 3p, \pm 5p....,$ vdw epgejidfspy njhFgad trR rpWkkhFk›

$$q = \tan^{-1} \frac{a_2 \sin f}{a_1 + a_2 \cos f}$$

$$A_{min} = \sqrt{(a_1 + a_2)^2}$$

xsprnrwpT› trrpd ,UkbfF Nehtpfpjjpy ,UfFk

$$I \mu A^2$$

,UGwKk ,Ukbahff›

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos f$$

flNtWghL $f = 0, \pm 2p, \pm 4p...,$ vdgJ xsparpd ngUkr nrwptpwfhd epgejidahFk. ,jwF MfffFWfflL tpisT vdW ngah.

njhFgad ngUk xsprnrwpT›

$$I_{max} \mu (a^1 + a^2)^2$$

$$I_{max} = I_1 + I_2 - +2\sqrt{I_1 I_2}$$

fllNtWghL $f = \pm p, \pm 3p, \pm 5p$ ...., vdgJ xspapd rpWkr nrwptpwfhd epgejidahFk. ,jwF mopTfFWfflL tpisT vdW ngah.

njhFgad rpWk xsprnrwpT›

$$I_{min} \mu (a_1 - a_2)^2$$

$$I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2}$$

rpwgG Nehthf $a_1 = a_2 = a$ vdpy› rkdghL khwwkilAk›

$$A = \sqrt{2a^2 + 2a^2 \cos f} = \sqrt{2a^2(1+\cos f)}$$

$$= \sqrt{2a^2 \cos^2(f/2)}$$

A = 2acos (f /2)

I µ 4a^2 cos^2 (f /2) [Q I µ A^2]

I = 4 I$_0$ cos^2 (f /2) [Q I_0 µ a^2]

I_{max} = 4I_0 vdpy $f = 0, \pm 2p, 4p$....,

I_{min} = 0 vdpy›$f = \pm p, \pm 3p, \pm 5p$....,

,uzL xsp miyfSk rejpfFk Gsspay VwgLk xsprnrwpit› ,ttpuzL miyfSffpilNa css fllNtWghL f jhkhdpffpwJ vdgij ,jpypUeJ ehk mwpayhk.

fl;lNtWghL kwWk; ghijNtWghL (Phase difference and Path difference)

mjpht[d Nfhz epiyfFf fllk (Phase) vdW ngah. miy guTkNghJ› miyapy css mjpht[d flepiyfFk› miy fleJ nrdw ghijfFkpilNa xU njhlhG csJ. miy xdwpd flepiyia› mttiy fleJ nrdw ghijia› mttiyapd flepiyapd mbggilapYk tpthffyhk. miy xdwpd ghij Xh miyesk tpwFr rkkhd fllk 2p MFk. f fllNtWghlbwFr rkkhd ghijNtWghL δ gpdtUkhW

$$d = \frac{l}{2p} \acute{} f \text{ myyJ } f = \frac{2p}{l} \acute{} d$$

Mfff FWfflL tpistpwF› fllNtWghL $f = 0, 2p, 4p$ vdNt› ghijNtWghL

δ = 0, λ, 2λ nghJthf miyesjjpd KO vz klqfhf ,UfFk.

$\delta = n\lambda$,qF, n = 0, 1, 2, 3 .....

mopTf FWfflL tpistpwFf fllNtWghL $f = p, 3p, 5p$.... vdNt› ghijNtWghL $d = \frac{l}{2}, \frac{3l}{2}, \frac{5l}{2}$

nghJthf miu miyesjjpd KO vz klqfhf ,UfFk.

$$\delta = (2n-1)\frac{l}{2} \text{ ,qF } n = 1, 2, 3$$

Xhpay; %yq;fs; (Coherent Sources)

,uzL miy %yqfs Xhpay %yqfshf ,Uff Ntz Lnkdpy› mit ,uzLk xNu fllNtWghlilfnfhzl myyJ xNu flljij cila miyfis cUthff

NtzLk. NkYk mttuzL miy%yqfSk xNu mjhntz myyJ miyesk (xwiw ewk) nfhzl miyfis cUthff NtzLk. mttiyfs xNu trR nfhzl miytbtk nfhzljha ,UggJk tUkgjjffJ.

Xhay jdik miyfsd gzghFk. ,ggzG eiyahd FWfflL mikgigg ngWtjwF mbggilahFk.

,uzL jdjjd xwiw ew xs %yqfs xhay %yqfs MfhJ. Vnddy› mit xNu mjhntz kwWk xNu trR nfhzl miyfis cUthffyhk. Mdhy› mtnths %yqfsdhy xNu flljjy css miyfis cUthffKbAk. ,jwfhd fhuzk vddntdwhy› mZffs xsia ckOkNghJ VwgLk ntgg mjhT fllkhwwjij VwgLjj tLfdwJ. vdNt› jdjjd xs%yqfs vgNghJk Xhay %yqfshfr nraygl KbahJ.

Xhay xs miyfisg gdtUk %dW toKiwfsy ngwyhk.

1. miyKfgGg ghgG
2. xsrnrwT (myyJ) trRg ghgG
3. xs%yk kwWk gkgqfs

miyKfgGg ghgG: Xhay xs %yqfisg ngWtjwfhd nghJthd xUKiw miy KfgGgghgG MFk. ehk mwejgb. Gss xs%yk xdW Nfhsf miyKfgig VwgLjJk. ,ej miyKfggy css xtnthU GssAk xNu flljjy ,UfFk. ,ulilg gsT xdwidg gadgLjj miyKfggYss ,uzL Gssfisj NjhT nrajhy mttuzL GssfSk Xhay xs %yqfshfr nraygLk.

xsrnrwT (myyJ) trRg ghgG:
gFj ntssGrggll fzzhb (fwiwg ghgghd) toNa xsiar nrYjJkNghJ› xNu Neujjy xs vjnuhsgG kwWk xstyfy ,uzLk VwgLk. xNu xs%yjjyUeJ ,uzL xsffwiwfisg ngWtjhy› ghffggll ,ttuzL xsffwiwfSk Xhay xsffwiwfshfr nraygLk. ,ttuzL Xhay xsffwiwfSk xNu flljjy myyJ khwhj fllNtWghlby cssd. ikffyfd FWfflLkhd (interferometer), ghgh – ngNuh ,izahb mikgG (etalon) Mfa fUtfs ,jjjJtjjd mbggilay nraygLfdwd.

xs%yk kwWk gkgqfs:

xs%yKk mjd gkgqfSk Xhay xs %yjnjhFgghfr nraygLfdwd. Vnddy› xs%yKk mjd gkgKk xNu flljjy css myyJ xNu fllNtWghlilAila xs miyfisf NjhwWtfFk. gnudy (Fresnel's) ,ulil Kgglfjjy ,uzL kha gkgqfs ,uzL Xhay %yqfshfr nraygLfdwd. NkYk yhal (Lloyd's) fzzhbay xU xs %yKk mjd kha gkgKk ,uzL Xhay %yqfshfr nraygLfdwd.

,ulilg gsT› Xhay %yqfshff nraygly (Double slit as coherent sources)

miyKfgGgghgGjjJtjij mbggilahff nfhzL ,ulilg gsT nraygLfdwJ. xwiw ew xs %yk S xdwdhy xsAllggll S1 kwWk S2 vdw ,uzL

gsTfs> Xhay xs%yqfshfr nraygLfdwd. ,twwyUeJ tUk xs miyfs xNu Clfjjy gazk nraJ xdWld xdW NkwnghUeJfdwd. ,twwhy VwgLk Mff kwWk moTf FWfflL tisTfs fhllgglLssd. miyfsd KfL njhlhrrahd NfhLfsdhYk mfL njhlhrraww NfhlbdhYk fhllgglLssd

Xh miyad mfLk> kwNwhh miyad mfLk (myyJ) Xh miyad KfLk kwNwhh miyad KfLk rejfFk Gssfsy css miyfs xNu flljjy cssd. vdNt> ngUk ,lgngahrr VwglL Mfff FWfflL tistdhy mgGssfs ngUk xsrnrwTld nghythff fhlr msfFk.

Xh miyad KfLk> kwNwhh miyad mfLk rejfFk Gssfsy css miyfs VwglL moTf FWfflL tistdhy mgGssfs fUikahff fhlrasfFk.

jiuay mLjjLjJg ngUk kwWk rWk xsrnrwTg glilfs NjhdWk. ,tthW jiuay NjhdWk nghyT kwWk fUikglilfs FWfflL thfs (fringes) vd mioffggLfdwd.

aq; ,ul;ilg; gsT Ma;T (Young's double slit experiment)
Ma;T mikgG

1801 Mk MzL jhk] aq vdw ghlb~ ,awgay mwQh fhlbAssthW> xsGfhj jiuay S_1 kwWk S_2 vdw ,uzL Jisfis VwgLjj mit S vdw xs%yjjyUeJ rknjhiytiy ,UfFkgb mikjjhh. xtnthU Jisad mfyKk 0.03 mm ,ttuzL JisfSk 0.3 mm njhiytiy ghjJ itffgglld. Jisfs S_1 kwWk S_2 ,uzL xs%yk S ,yUeJ rknjhiytiy cssjhy> xs%yk S ,yUeJ S_1 kwWk S_2 it milAk miyfs xNu flljjy ,UfFk. vdNt> FWfflL tisit VwgLjJk Xhay %yqfshf S_1 kwWk S_2 gsTfs nrayglLf FWfflL tisit VwgLjJk.

gsTfs S_1 kwWk S_2 tyUeJ tUk miyKfgGfs ,ulilggstd tyggffkhf guTfdwd. gsTfsyUeJ Rkhh 1 m njhiytiy jiuaid itfFkNghJ> mjjiuay rk mfyKila nghyT kwWk fUik thfs mLjjLjJj NjhdWfdwd. ,jwF FWfflLgglilfs (myyJ) FWfflL thfs vdW ngah. fz zUFtiyiy xwiwg gadgLjj ,fFWfflL thfis Neubahff fhzyhk. S_1, S_2 tyUeJ jiuaid ikagGss O it milAk xsmiyfs> rknjhiyitf fleJteJssjhy mit fhlbAssthW xNu flljjy ,UfFk. ,ttuzL miyfSk MfffFWfflL tisit VwgLjj> ikagGss O tiy

nghyTthia cUthfFk. ,jwF ikag nghyTth vdW ngah. VNjDk xU gsit %btllhy FWfflLthfs kiweJ jiu ruhf xsA+llgglbUfFk. ,jyUeJ> jiuay NjhdWk nghyT kwWk fUik thfs xsad FWfflL tistdhy Vwgllit vdgij mwayhk.

ghij NtWghbw;fhd rkd;ghL
Xhay %yqfshfr nraygLk S_1 kwWk S_2 gsTfSffilNa css njhiyT d vdf.

,it λ miyesKila xs miyfis cUthfFk. ,ulilg gsTfSfF ,izahf D njhiytiy jiu xdW itffgglLssJ. S_1 kwWk S_2 fF eLNt css Gssia C vdf. NkYk> jiuaid ikagGss O. S_1 kwWk S_2 tyUeJ rknjhiytiy cssJ. jiuay ikagGss O tyUeJ Y njhiytiy css

VNjDk XU Gsspia Pvdf. S_1, S_2 tpyUeJ PGsspia milAk xsp miyfs> mtwwpwF ,ilNa csss ghij NtWghlilg nghUjJ> xNu flljjpNyh myyJ vjph vjph flljjpNyh ,UfFk.

S_1 kwWk S_2 tpyUeJ PGsspia milAk xsp miyfSfF ,ilNaAss ghij Ntghlil δ vdf. $\delta = S_2P - S_1P$

S_1 ,y ,UeJ> S_2P NfhlbYss MGsspfF tiuaggll nrqFjJf Nfhlbypy UeJ ghij NtWghlilj Jyypakhff fzffplyhk.

$\delta = S_2P - MP = S_2M$

CGsspaypUeJ> P Gssp mikeJss Nfhzepiyia θ vdf. ĐOCP = θ tbtpay tpjpfspd gb>

Nfhzqfs ĐOCP kwWk ĐS_2S_1M Mfpait rkk.

Đ OCP = $S_2S_1M = \theta$

nrqNfhz KfNfhzk Δ S_2S_1M ,y> ghijNtWghL $S_2M = d\sin\theta$

$\delta = d\sin\theta$

Nfhzk θ rpwpaJ vdNt> $\sin\theta = \tan\theta = \theta$

nrqNfhz KfNfhzk ΔOCP

$$\tan\theta = \frac{y}{D}$$

ghijNtWghL> $d = \frac{dy}{D}$

ghij NtWghlbd epgejidiag nghUjJ> Gsp Papy nghypT thpNah (myyJ) fUik thpNah NjhdWk.

nghypT thp mypyJ ngUkjpwpfhd epgejid

MffFWfflL tpisT myyJ PGsspapy nghypTthp Njhdw epgejid gpdtUkhW>

ghijNtWghL $d = nl$

,qF $n = 0, 1, 2 .....$

$$\therefore \frac{dy}{D} = nl$$

$$y = n\frac{yD}{d} \text{ myy } y_n = n\frac{yD}{d}$$

PGsspapy nghypTthp Njhdw ,JNt epgejidahFk. ,qF y_n vdgJ O tpyUeJ n tJ nghypTthpapd njhiyitf Fwpffpwj.

fUik thp mypyJ rpWkjpwpfhd epgejid

mopTfFWfflL tpisT myyJ PGsspapy fUikthp NjhdWtjwfhd epgejid gpdtUkhW>

gpdtUkhW>

ghijNtWghL> $d = (2n-1)\frac{l}{2}$

,qF n = 1, 2, 3.....

$$\therefore \frac{dy}{D} = (2n-1)\frac{l}{2}$$

$$y = \frac{(2n-1)}{2}\frac{l D}{d} \text{ myyJ } \quad y_n = \frac{(2n-1)}{2}\frac{l D}{d}$$

fUikthp NjhdWtjwfhd epgejid gpdtUkhW›

$$y = \frac{(2n-1)}{2}\frac{l D}{d} \text{ myyJ } \quad y_n = \frac{(2n-1)}{2}\frac{l D}{d}$$

PGssparay fUikthpj Njhdw ,JNt epgejidahFk. ,qF y_n vdgJ› *O* typUeJ *n* tJ fUikthpfs njhiyitf Fwpfpwj. nghypT kwWk fUikthpfs NjhdWk tpjjijg fhlLfpdwJ.

jpiuapy› ikagnghypTthpad ,uzL gffqfspYk nghypT kwWk fUikthpfs mLjjLjJj NjhdWk. ikagnghypitr Ropgnghypt vdTk (0th bright) mjd njhlhrrpahf Kjy fUik kwWk Kjy nghypT NjhdWk. mLjJ ,uzlhtJ fUik kwWk ,uzlhtJ nghypT NjhdWk. ,tthwhf› ikagnghyptpd ,uzL gffqfspYk csthW fUik kwWk nghypTgglilfs mLjjLjJj NjhdWk.

glpil mfyjpjpwfhd Nfhit

,uzL mLjjLjj ngypTthp myyJ fUikthpfSfF ,ilNa css njhiyT glil myfk (β) vd mioffggLfpwJ.

ikagGsspO typUej *(n+1)* tJ nghypTthpfFk› *n* tJ nghypTthpfFk ,ilNa css njhiyT glil mfyjijf nfhLfFk.

$$b = y_{(n+1)} - y_n = \left(n+1\right)\frac{l D}{d} - n\frac{l D}{d}$$

nghyptpwfhd› $b = \frac{l D}{d}$

,tthNw› ikagGsspO typUeJ (n+1) tJ fUikthpfFk *n* tJ fUikthpfFk ,ilNa css njhiyT› glil mfyjijf nfhLfFk.

$$b = y_{(n+1)} - y_n = \frac{(2(n+1)-1)}{2}\frac{l D}{d} - \frac{(2n-1)}{2}\frac{l D}{d}$$

fUikffhd› $b = \frac{l D}{d}$

ikagnghypT› thpad ,UGwKk mf mfyKila nghypT kwWk fUikthpfs rk ,ilntspay NjhdWk vdW mwpayhk.

njspthd kwWk; mfykhd FWf;fl;Lg; thpfisg; ngWtjwfhd epgejidfs;

1. xspa%yjjpwFk jpiufFk ,ilNaAss njhiyT D kpf mjpfkhf ,Uff NtzLk.
2. gadgLjjggLk xspapd miyesk λ kpf mjpfkhf ,Uff NtzLk.
3. ,uzL gpsTfSfF ,ilNaAss njhiyT d kpff Fiwthf ,Uff NtzLk.

gytz;z xspapdhy; VwgLk; Fwf;fl;L tpisT

gytzz xspapidf nfhzL (ntsis xsp) epfojjggLk FWfflL tpisTfspy nttNtW epwqfs nfhzl tzzthpfs jpiuapy NjhdWk. ,jwFf fhuzk› nttNtW tzzqfs nttNtW miyesqfisg ngwwpUggjhFk. ,UejNghjpYk› ikath myyJ Ropth vgNghJk nghypthfTk› ntzik epwjjpYk fhzggLk.

,jwFf fhuzk ikak O tpy tpOk midjJ tzzqfSfFk ghijNtWghL RopahFk. vdNt› midjJ tzzqfSfFk ikagGsspO tpy MfffFWfflL tpisT klLNk eilngwW› ikak nghypthff fhlraspfFk.

ehpd kJ glhejpUfFk vznzag glyk kwWk NrhgGfFkpo Nghdwit Nghy fzfth tzzqfis ntspggLjJfpdwd gljjpy fhllgglLssJ) ,ttzzqfSfFf fhuzk nkyNyLfspd NkwgugG kwWk mbggugpwF ,ilapy gyKiw vjpnuhspgG milej ntsis xspffjphfspd FWfflL tpisthFk. ,ttzzqfs nkyNyLfspd jbkd› nkyNyLfspd xsptpyfy vz kwWk xspapd gLNfhzk Mfpatwiwr rhhejjhFk.

nkypNyLfspy; VwgLk; FWf;fl;L tpisT (Interference in thin files)

xsptpyfy vz (FWfflLg glilapd thpir *n* cld NrhjJ Foggpf nfhssf$lhJ vdgjwfhf µ vdW nfhLffgglLssJ) kwWk jbkd *d* nfhzl nkyNyL xdiwf fUJNthk. ,knkyNylbd fhlbAssthW ,iz xspffwiw xdW *i* vdw gLNfhzjjpy tpOfpwJ. ,ej xsp gLGsspapy vjpnuhspggilAk gFjp kwWk tpyfyilAk gFjp vdW ,uzlhfg gphpfpwJ. xsptpyfy milej gFjp nkyNylbd csNs nrdW nkyNylbd mbggugpy NkYk ,uzL gFjpfshfg gphpfpwJ. xUgFjp nkyNylbid cLUtp ntspNaWfpwJ. kwnwhU gFjp nkyNylbd clGwk gyKiw vjpnuhspgG miltjhy› NkYk vjpnuhspgG kwWk xsptpyfyilej gFjpfs cUthfpdwd. ,knkyNylbdhy vjpnuhspgG kwWk CLUty milej xU miyfs jdpjjdpNa FWfflL tpisit VwgLjJfpdwd.

cLUtpr; nrdw VwgLk; FWf;fl;L tpisT

CLUtpr nrdw xsp miyfs FWfflL tpisit VwgLjjpj njhFgad xsprnrwpitf nfhLfFk. B kwWk D Gsspfspy;UeJ CLUtprnrdw xsp miyfspd ghij NtWghlilf fUJNthk. xsp miyfs ,uzlhfg gphpif milAk B Gssptiu ,uzL xsp miyfSk xdwhfNt nryYk. vdNt› ,uzL miyfSk xjjfllljjpy ,UfFk. D Gsspp topahf CLUtpr nryYk xsp miy nkyNylbd csNs fleJnrdw $Ljy ghij BC + CD MFk› xsp miy nkyNylbd csNs nrqFjJg gLfjph epiyapy NkhJfpwJ vdWk (*i = 0*) Vlbd jbkz kpff FiwT vdWk fUjpdhy› B kwWk D Gsspfs ,uzLk xdWfnfhdW kpf neUffkhf mikeJssJ vdyhk. vdNt› xsp miy fleJnrdw $Ljy ghij Njhuhakhf *BC + CD = 2d.* xsptpyfy vz µnfhzl Clfjjpd csNs ,f$Ljy ghij cssjhy› xsapay ghijNtWghL $\delta = 2\mu d$

CLUtpr nrdw miyfspdhy VwgLk MfffFWfflL tpistpwfhd epgejid›

$$2\mu d = n\lambda$$

,NjNghdW› CLUtpr nrdw miyfspdhy VwgLk mopTf FWfflL tpistpwfhd epgejid›

$$2\mu d = (2n - 1)\frac{l}{2}$$

vjpnuhspgG milej xspapdhy; VwgLk; FWf;fl;L tpisT

nfhsifujpahf kwWk Nrhjidfspd %ykhfTk mlhFiw Clfjjpd topahfr nrdW› mlhkpF Clfggugpdhy vjpnuhspgG milAk xsp miyfs *p* vdw

flNtWghlil ngWk vd e&gffgglLssJ. vdNt› vjnuhsgG milej xsfF $Ljy ghijNtWghL λ/2 itf fUjNtzLk.

nkyNylbd Nkwgugg y A Gssay vjnuhsgG milej xsfFk. nkyNylbyUeJ C Gss toahf ntsNaWk miyfFk ,ilNaahd ghij NtWghlilf fUJf. C GssayUeJ ntsNaWk NkNylilg nghWjjtiu nkyNylbd csNs $Ljyhff fleJtej ghij AB + BC. nrqFjJg gLNfhz eiyay› ,f$Ljy ghijaid njhiyT Njhuhakhf AB + BC = 2d ,f$Ljyghij μ xstyfy vznfhzl Clfjjds cssjhy› xsaid ghijNtWghL δ = 2μd MFk.

vjnuhsgG miyfsdhy VwgLk moTf FwfflL tistwfhd egejid

$$2\mu d + \frac{l}{2} = n\lambda \ (m) \ 2\mu d = (2n-1)\frac{l}{2}$$

mlhFiw Clfjjy A Gssay mlhkF nkyNylLg guggdhy vjnuhsgG milejjhy *p* flNtWghlil ngWfwJ. vdNt› ,f$Ljy ghijNtWghL l/2 ,qF VwgLfdwJ.

vjnuhsgG miyfsdhy VwgLk moTf FWfflL tistwfhd egejid

$$2\mu d + \frac{l}{2} = (2n+1)\frac{l}{2} \quad (m) \ 2\mu d = n\lambda$$

nrqFjJg gLNfhz eiyay xs miy nkyNyL guggd kJ tohky› NtW xU Fwggll gLNfhzk *i* y tOejhy› mjwfhd tyFNfhzk *r* MFk. vdNt› ghij NtWghlbwfhd Nkwfzl rkdghlbd ,lggffk css $2\mu d$ vdw $2\mu d \cos r$ gjk vd khwwkilAk.

tsgkG tisT (Diffraction)

tsgkG tidahdJ midjJ miyfSfFkhd nghJthd gzG ,jy xy miyAk mlqFk. jilaid tsgkgy tiseJ nrdW› jilaid tbtay ujahd eoYfFs miy nryYk efoTfF tsgkG tisT vdW ngah. fjh xsaayy ehk gadw xsaid NehNfhlLggutYfF ,J vjuhdjhFk. Mdhy› jilaid msT xsaid miyesjJld xggljjff mstpy fhzgglhy klLNk tsgkG tisT VwgLk. ,jd fhuzkhfjjhd. fjTfs› [ddyfs kwWk flllqfsdhy xy miyfs tsgkG tisT milfdwd. xyaid miyesk ,jjilfsd msTld xggljjff mstpy cssJ. xsaYk tsgkG tisT Vwgl› jilaid msT xsaid miyesjJld xggljjff mstpy ,Uff NtzLk.

gnudy; kwWk; guhNdh/gh; (Fresnel and Fraunhofer) **tsgkG tisTfs;**

tsgkG tistilAk miyKfggd tbtjijg nghUjJ gnudy kwWk guhNdh/gh tsgkG tisT vd ,UtifggLjjyhk. gnudy kwWk gnuNdh/gh tsgkG tisTfSffilNaahd NtWghLfs fhllgglLssJ.

gnudy; kwWk; guhNdh/gh; tsgkG tisTfSf;F ,ilNaahd NtWghLfs;

t.vz;	gnudy; tsgkG tisT	guhNdh/gh; tsgkG tisT
1.	Nfhsf (myyJ) cUis tbt miyKfgG tsgkG tistwF clgLfdwJ.	rkjs miyKfgG tsgkG tistwF clgLfdwJ
2.	xs miyfisf nfhLfFk	xs miyfisf nfhLfFk xs

	xs;%yk› tukGfFlgll njhiyt;y ,UfFk	%yk› <h;yyhj njhiyt;y ,UfFk
3.	Matf #oy;y› Ft;nyd]fs gadgLjj Ntzbaj;yiy	Matf #oy;y› Ft;nyd]fs gadgLjjggl NtzLk.
4.	cwW Nehffy kwWk MaT nratJ fbdk	cwW Nehffy kwWk MaT nratJ vs;J
5.		

cwW Nehffy kwWk MaT nraa guhNdh/gh t;s;kG t;isT vs;ajhf ,Uggjhy guhNdh/gh t;s;kG t;isT.

xw;iwg; g;st;y; vwgLk; t;s;kG t;isT (Diffraction at single slit)

AB mfyk nfhzl xwiwg g;sT xdw;d kJ nrqFjjhf t;Ok ,iz xs;ffwiwiaf (rkjs miyKfgG) fUJNthk. t;s;kG t;istilej xs;ffwiw› g;st;y;UeJ D njhiyt;y itffgglLss j;iua;y t;Of;wJ g;st;d ikajij O vdf. g;st;d jsjj;wFr xs;ffwiw› g;st;y;UeJ D njhiyt;y itffgglLss j;iua;y t;Of;wJ g;st;d ikajij O vdf. g;st;d jsjj;wFr nrqFjjhf C Gss; to;Na nryYk NehNfhL j;iua;y O vdw Gss;ia milf;wJ. j;iua;y g;st;d nttNtW Gss;fs;y ,UeJ P l milAk xs;ffj;hfs nrqFjJf NfhNlhL θNfhzjij VwgLjJf;dwd.

g;st;d nttNtW Gss;fs;y;UeJ tUk ,iz xs; miyfs j;iua;y P Gss; kwWk ,ju Gss;fs;y xdiw xdW FWff;lLj njhFgad xs;rnrw;itf nfhLff;dwd. P Gss;› tbt;ay uj;ahd e;oy gFj;a;y cssJ. t;s;kG t;ist;d fhuzkhf› ,ggFj; tiu ikagngUkk gut; fhzggLf;wJ j;iua;y css Gss; P nttNtW r;Wkqfis miltjwfhd e;gejidfisf ehk fhzNtzLk. g;sit ,ulilggil vzz;fifAila r;WrW gFj;fshfg g;hj;Jf nfhzlhy mggFj;fs;y;UeJ tUk xs; miyfs;d ghijNtWghLfs xdw;idjJ› P Gss;a;y mo;Tf FWffIL t;isit VwgLjj› r;Wk xs;r nrw;it czlhfFf;wJ. ngUkqfis t;sfFtjwF› g;sit xdiwggil vzz;fifAila r;WgFj;fshfg ghhjJfnfhss NtzLk.

P Gs;s;a;y; Kjy; r;Wkk; VwgLtjw;fhd e;gejid

g;sT AB I AC kwWk CB vdw ,uzL miuggFj;fshf g;hj;Jf nfhss NtzLk. xtnthU gFj;a;d mfyKk *a/2*. ,gNgh J› g;st;y *a/2* J}uKila nttntW Gss;fSfF xgG Gss;fs (Corresponding points) vdW ngah.

nttNtW xgg Gss;fs;y;UeJ tUk xs; miyfs P Gss;a;y xdWld xdW NkwnghUej; mo;Tf FWffIL t;isit VwgLjj› Kjy r;Wkjij VwgLjJf;wJ.

xgG Gss;fs;y;UeJ tUk xs; miyfs;d ghijNtWghL› $d = \frac{a}{2}\sin q$

P Gss;a;d Kjy r;Wkk NjhdWtjwfhd e;gejid $\frac{a}{2}\sin q = \frac{l}{2}$

$$a \sin\theta = \lambda$$

P Gs;s;a;y; ,uz;lhtJ r;Wkk; NjhdWtjw;fhd e;gejid

AB gsit *a/4* mfyk nfhzl ehdF gFjfshfg gh‰jJf nfhss Ntz Lk. gstd eLNt *a/4* J}uk nfhzl xgg Gsstfsy‰UeJ tUk xs‰ miyfSfF ,ilNaahd ghijNtWghL› $d = \frac{a}{4}\sin q$

PGsstay ,uzlhk r‰Wkk NjhdWtjwfhd e‰gejid› $\frac{a}{4}\sin q = \frac{l}{2}$

$$a\sin q = 2l$$

PGs‰sta‰y; %dwhtJ r‰Wkk; VwgLj‰Jtjw‰fhd e‰gejid

Kddh $w‰athNw› gsit MW rk gh‰TfshfgF gh‰jJfnfhss Ntz Lk. PGsstay %dwhtJ r‰Wkk VwgLtjwfhd e‰gejid› $\frac{a}{6}\sin q = \frac{l}{2}$

$$a\sin q = 3l$$

PGs‰sta‰y; ntJ r‰Wkk; Vwgl e‰gejid

gsit› *2n* vz z‰fifAila (,uzil ,yff vz z‰fif) rkgFjfshfg gh‰jJfnfhss Ntz Lk. Xh xgG Gsstay‰UeJ tUk xs‰ miyia kwNwhh xgG Gsstay‰UeJ tUk xs‰ miy mo‰fFk e‰iyay n tJ r‰Wkk

Vwgl e‰gejid› $\frac{a}{2n}\sin q = \frac{l}{2}$

$$a\sin q = nl$$

,qF *n* vdgJ t‰skG t‰isT r‰Wkjjd thir n = 1, 2, 3 .....

ngUkq‰fSf‰fhd e‰gejid

ngUk xs‰rnrw‰T Vwgl› gsit xwiwggil vz z‰fifAila rkgFjfshfg gh‰jJfnfhss Ntz Lk. ,tthW gh‰ggjdhy VjhtJ xU xgG Gsstay‰UeJ tUk xs‰ miy mo‰ffgglhky ,UfFk. vdNt› PGsst ngUk xs‰rnrw‰tiy fhzggLk. Kjy ngUkjj‰wfhd e‰gejid›

$$\frac{a}{3}\sin q = \frac{l}{2} \text{ (myyJ) } \frac{a}{3}\sin q = \frac{3l}{2}$$

,uzlhk ngUkjj‰wfhd e‰gejid›

$$\frac{a}{5}\sin q = \frac{l}{2} \text{ (myyJ) } a\sin q = \frac{5l}{2}$$

%dwhk ngUkjj‰wfhd e‰gejid›

$$\frac{a}{7}\sin q = \frac{l}{2} \text{ (myyJ) } a\sin\theta = \frac{7l}{2}$$

,NjNghdW› ntJ ngUkjj‰wfhd e‰gejid

$$a\sin\theta \frac{l}{2} \text{ (ntJ ngUkk)}$$

,qF n = 0, 1, 2, 3...., vdgJ ngUkqfsd thirahFk.

ika thir ngUkjj‰wF› Ro‰ thir ngUkk vdW ngah. mLjjLjj r‰WkqfSfF f‰lljjll eLNt ngUk xs‰rnrw‰T fhzggLk.

,qF $\sin\theta$ vdgJ tpsikG tpistpd Nfhz gutiyf nfhLffpwJ. Njhuhakhffypd mbggilapy jpiuapd ikajjpypUeJ $\frac{y}{D}$ njhiytpy mikeJss ngUkk myyJ rpWkjjpd epiyia $\sin\theta$ tpwF gjpyhf $\tan\theta$ nfhzLk tpthpffyhk. (Vnddpy kpfTk rpwpaJ) vdNt $\sin\theta = \tan\theta = \frac{y}{D}$

,qF y vdgJ jpiuapd ikajjpypUeJ ngUkk myyJ rpWkk mikeJss epiyiaf Fwpffpwj. NkYk D vdgJ xdiwggpstpypUeJ jpiu css njhiyitf Fwpffpwj.

Kjy; rpWkj;ijg; gwwpa tpsf;fk;

xwiwg gpsT tpsikG tpistpy Kjy rpWkjjpd rkdghL $a\sin\theta = \lambda$ Kjy rpWkjjpd Nfhzg guty; $\sin\theta = \frac{\lambda}{a}$. ,Ugffqfspypk cUthFk Kjy rpWkqfSfF eLtpy ika ngUkk fhzggLk ,jwfhd rpwgG NehTfis ,qF fhzNghk.

1. $a = \lambda$ vdpy; $\sin\theta = 1$. mjhtJ $\theta = 90°$. ,jd nghUs Kjy rpWkk $90°$,y VwgLfpwJ vdgjhFk. vdNt; tbtpay ujpahd epoy gFjp KOtJk ikagngUkk gutp; tpsikG tpisTf fjpiu $90°$ tisffpwJ.

2. $a > \lambda$ kwWk miyesjJld xggpljjfff mstpy mikAk NghJ mjhtJ; $a = 2\lambda$ vDkNghJ; $\sin\theta = \frac{1}{2}$. vdNt $\theta = 30°$. fzprkhd gutYld tpsikG tpisT fhzggLfpwJ. MfNt; tpsikG tpisT njspthf fhzggLtjwF gpstpd mfyk *a* MdJ xspapd miyesk λ it tpl xU rpy klqFffshf ,Ujjy NtzLk vdgJ njspthfpwJ.

3. $a >> \lambda$, tpwF $\sin\theta << 1$ mjhtJ; Kjy rpWkk gpstpd mfyjjpwFsshfNt mikAk. vdNt; tpsikG tpisitf fhz ,ayhJ.

gnudy; njhiyT

tpsikG tpisT epfotpy xspmiy tiseJ nryYk ,ej xspapd tisAk gzG mjd NehNfhlL gutYffF Kwwpyk vjpuhdjhFk. tpsikG tpisT milej fjph; gpstpypUeJ z njhiytpy ika ngUkjjpd msit tplf $Lk tiu ,ej tiseJ nryYk ,ayG fhzgglhJ. vdNt; vejj njhiyT tiu xspahdJ fjph xspapaYffF clgLfpwNjh myyJ vejj njhiyTffF mgghy fjph xspapaYffF clglhky miy xspapaYffF clgLfpwNjh mejj njhiyT gnudy njhiyT vdggLk.

Kjy rpWkjjpwfhd tpsikG tpisTr rkdghL $\sin\theta = \frac{\lambda}{a}$; $\theta = \frac{\lambda}{a}$ (Q θ rpwpajhdjhy)

gnudy njhiytpd tiuaiwapypUeJ;

$2q = \frac{a}{z}$ (myyJ) $q = \frac{a}{2z}$

,uzL rkdghLfisAk xggpLkNghJ;

$$\frac{l}{a} = \frac{a}{2z}$$

vdNt› gnudy njhiyT z

$$z = \frac{a^2}{2l}$$

FWf;fl;L t;istpwFk; t;spkG t;istpwFk; cs;s NtWghLfs;

FWfflL t;isT kwWk t;spkGt;isT ,uz ilAk NtWgLjj;gghhggJ k;fTk fbdkhFk. Vndd;y› ,ttuzL gzGfSk xs;a;d miyggzig nts;ggLjJf;dwd. ,ttuzL e;foTfs;YNk› j;iua;y cUthFk ngUkqfs kwWk r;WkqfSfF FWfflL t;isTk tbt;ay e;fwgFj;a;y xs; guTjYfF t;spkG t;isTk fhuzkhf mikf;dwd. FWfflL t;ist;y NkwnghUeJjYk t;spkG t;ist;y xs;a;d tiseJ nryYk jdikAk Kff;ajJtk ngWf;dwd. ,UejNghj;Yk. ,ttuzL t;isTfs;d Njhwwjj;d mbggila;y g;dtUk NtWghLfs fzLzugglL nfhLffgglLsd.

fw;wz;a;y; VwgLk; t;spkG t;isT (Diffraction in grating):

t;spkG t;isTf fwwz;a;y rk mfyKila› mj;f vzz;fifa;y mikej g;sTfs fhzggLf;dwd. g;sTfs;d mfyk t;spkG t;istilAk xs;a;d miyesjJld xgg;ljjff mst;y mikej;UfFk. xs;GFk nghUs;d kJ xs;GfhfNfhLfs tiuagglbUfFk. tz;fuj;a;y nraaggLk etd t;spkG t;isTf fwwz;a;y xU nrdbkllh;y 6000 xs;Gfhf NfhLfs tiaugglbUfFk. jilNghdW nraygLk› xs;Gfhf NfhLfs;d mfyjij *b* vdTk. xs;Gfhf NfhLfSfF eLNt mikeJss JisNghdW nraygLk xs;GFk gFj;a;d mfyjij *a* vdTk nfhsf. Xh xs;GFk g;sT kwWk Xh xs;Gfhf NfhL Mf;atww;d nkhjj mfyjj;wF fwwz;%yk (*e* = *a* + *b*) vdW ngah. mLjjLjj g;sTfs;y css› fwwz;%yjj;wFr rkkhd njhiyt;y mikeJss Gss;fSfF xgG Gss;fs vdWngah.

rkjs t;spkG t;isTf fwwz;AB lf fUJf. ,ffwwz;a;y› rk mfyk nfhzl mLjjLjj g;sTfSk› rk mfyk b nfhzl xs;GfhfNfhLfSk fhlbAssthW mikeJssd. λmiyesKila xwiwe;wr rkjs miyKfgG xdW fwwz;a;d kJ nrqFjjhf t;Of;dwJ vdf fUJf.

FWf;fl;L t;isT kwWk t;spkG t;isTfSf;F ,ilNa cs;s NtWghLfs;

t.vz;	FWf;fl;L t;isT	t;spkG t;isT
1.	nghy;T kwWk fUik th;fs xNu mfyk nfhzlit	kww th;fis t;l ika th;a;d mfyk ,U klqF
2.	vyyh nghy;T th;fSk f;lljjll xNu xs;rnrw;itg ngww;UfFk	cah th;ir t;spkG t;isT th;fs;d xs;rnrw;T Ntfkhaf FiwAk
3.	xs; th;fs;d vzz;fif mj;fk	xs; th;fs;d vzz;fif FiwT

fwwz;a;d kJ t;Ok xs;a;d miyesk› g;st;d mfyjJld xgg;ljjff mst;y cssjhy› fwwz;ahy mtnths; t;spkG t;isT milAk. Ft;nyd] xdiw gadgLjj; t;spkGt;istilej miyfis j;iua;dkJ Ft;jjhy› t;spkG t;isTggil mikgG f;ilfFk. fwwz;a;d ikajj;y;UeJ j;iufF tiuaggll nrqFjJf NfhlLld θNfhzjj;y mikeJss Pvdw Gss;iaf fUJf. xU N[hb mLjjLjj xjjGss;fs;y;UeJ nrdw t;spkG t;istilej miyfSff;ilNaahd ghijNtWghL

$$\delta = (a+b)\sin\theta$$

midjJ mLjjLjj N[hb xjjGsspfSfFk ,gghijNtWghL rkkhFk. P Gsspnghypd;Tld ,Uff

$$\delta = m\lambda$$,qF $m = 0, 1, 2, 3$ Nkwfzl ,uzL rkdghLfisAk xggpLkNghJ›

$$(a+b)\sin\theta = m\lambda$$

,qF *m* vdgJ tpspkG tpisT thpirahFk. Gsspd; *P* Rop thpirg ngUkkhf ,Uggjwfhd epgejid› $m = 0$

$(a+b)\sin\theta = 0$ vdpy› tpspkG tpisTf Nfhzk $\theta = 0$ kwWk $m = 0$,jwF Rop thpirg ngUkk myyJ ikagngUkk vdW ngah.

Gspsp P Kjy; thpirg; ngUkkhf ,Uggjwfhd epgejid $m = 1$

$(a+b)\sin\theta_1 = \lambda$ vdpy› tpspkG tpistilej xspahdJ gLk xspapd jpirAld θ_1 Nfhzjij VwgLjJk. NkYk› Kjythpirg ngUkk fpilfFk.

Gspsp P ,uzlhk; thpirg; ngUkkhf ,Uggjwfhd epgejid $m = 2$

$(a+b)\sin\theta_2 = 2\lambda$ vdpy› tpspkG tpistilej xspahdJ gLk xspapd jpirAld θ_2 Nfhzjij VwgLjJk. NkYk› ,uzlhk thpir ngUkk fpilfFk.

Gspsp *P, m*-MtJ thpirg; ngUkkhf ,Uggjwfhd epgejid

ikag ngUkjjpd ,uzL gffqfspYk nttNtW Nfhz epiyfspy cahthpirg ngUkqfs fpilfFk

,tthwhf vLjJfnfhzlhy›

$$N = \frac{1}{a+b}$$

fwwzpapy xuyF mfyjjpwF tiuaggll fwwzp %yqfs myyJ xspGfhf NfhLfspd vzzpfifia *N* nfhLfFk. nghJthf› fwwzpapNyNa *N* ,d kjpgG vOjgglbUfFk.
vdNt›

$$\frac{1}{N}\sin\theta = m\lambda$$ myyJ $\sin\theta = Nm\lambda$

xwiwggpsT Matpy rpWkjjpwfhd epgejid $a\sin\theta = n\lambda$,qF *n* vdgJ› rpWkqfspd thpiaf FwpfFk. Mdhy tpspkG tpisTf fwwzp Matpy ngUkjjpwfhd epgejid $\sin\theta = Nm\lambda$,qF *m* vdgJ ngUk tpspkG tpisT thpiriaf FwpfFk vdgij khzthfs ftdKld epidtpy itjjpUff Ntz Lk.

xwiwepw xspapd; miy esj;ijf; fhzgjwfhd Nrhjid

xspGFk tpspkG tpisTf fwwzpiaf nfhzL epwkhiythapd miyesjijj Jyypakhff fzlwpayhk. ,jwF epwkhiykhdp vdw fUtp Njitggl fpwJ epwkhiykhdpapd njhlff ruikgGfis nraa Ntz Lk. miyesk fhzNtzba xwiw epw xspapdhy ,izahffpapd gpstpid xspAll Ntz Lk. njhiyNehffpapid ,izahffpfF Neuhf mikjJg gpstpd Neub gpkgjjpidf fhz Ntz Lk ,izhaffpypUeJ tUk gLk xsp miyfFr nrqFjjhf csspthW tpspkG tpisTf fwwzpia Kgglf Nkil kJ mikff Ntz Lk. Kjy thpir tpspkG tpisT gpkgk› njhpAk tiu njhiy Nehffpapid xU gffkhfr

RowwNtzLk. njhiyNehff mikeJss epiyffhd mstLfisf FwpjJfnfhss NtzLk.

,NjNghdW kwnwhU gffkhf njhiyNehffpiar Rwwp Kjy thpir tpspkG tpisT gpkgjij rhpnrajgpd mstLfisf FwpjJf nfhssNtzLk. ,uzL epiyfSfFk ,ilNa css NtWghL

xU FWejfL (Compact disc) fzfth tzzqfspy gsgsffpdwJ. gjpT nraaggLbUfFk gsgsgghd gffjjpy tlltbt FWfpa ntlLfs fhzggLk. ,tntlLfspd mfyk fzZW xspapd miyesjJld xggpljjff mstpy cssjhy> ntsis xsp miyfs FWejfLfspd ,ggffjjpd kJ glL vjpnuhspfFk NghJ tpspkG tpisT VwglLf fzfth tzzqfspy FWejfLfs NjhdWfpdwd. ghlyfs kwWk glqfs gjpT nraaggLbUfFk gpsTfs tpspkG tpisTf fwwzp NghdW nraygLfpdwd.

2θ itf nfhLfFk. ,jd kjpggpy ghjp Kjythpir ngUkjjpwfhd tpspkG tpisTf Nfhzk θ itf nfhLfFk. xspapd miyesk gpdtUk fzffplggLfpwJ.

$$I = \frac{\sin q}{Nm}$$

,qF *N* vdgJ xU kllh esjjpy fwwzpapy tiuaggll NfhLfspd vzzpfifahFk. NkYk *m* vdgJ tpspkG tpisT gpkgjjpd thpirahFk.

nttNtW tzzqfspd miyesqfisf fzlwpjy;

ntsis xspiag gadgLjJkNghJ> ikagngUkKk mjd ,uzL gffqfspYk njhlhrrpahd tzz tpspkG tpisTgglilfs NjhdWk. ikagngUkk ntzikahf njhpAk> midjJ tpzzqfSk vttpj ghijNtWghLk ,dwp xdiw xdW tYTlLk tifapy ikajjpy xdwpiztjhy. θ mjfhpfFkNghJ> ghijNtWghL Cjh Kjy rptgG tiu css midjJ tzzqfspd ngUk tpspkG tpisT epgejidAk epiwNtwWk. ikagnghyptpd ,uzLggffqfspYk Cjh Kjy rptgG tiuAss epwkhiy mikgig cUthfFk. nttNtW thpirfisf nfhzl tpspkG tpisTf Nfhzqfisf fzlwpeJ> tzzqfspd miyesqfisg gpdtUk rkdghlbidg gadgLjjpf fzffplyhk.

$$I = \frac{\sin q}{Nm}$$

,qF *N* vdgJ fwwzpapy xU kllh esjjpy tiuaggll NfhLfspd vzzpfifiaAk> *m* vdgJ tpspkG tpisT gpkgjjpd thpiriaAk FwpfFk.

(xspapay;) gphpgG (Resolution):

gpkgqfspd Jyypajjdikiag nghWjjtiu tpspkG tpistpd jhffk tpUkgjjfhj xdwhFk. xwiwggpstpy ikagnghypT nghUspYss xtnthU GsspAk Gsspy;ykhfr nraygLtjhy> mjd gpkgjjpy xtnthU GsspapYk ikag ngUkk tphptileJ fhzggLk. nrttfg gpstpdhy VwgLk ikag ngUkk (myyJ Kjy rpWkk) %yk ngwggLk.

$$a\sin q = l$$

Mdhy xU tllg gpsT (myyJ Jis)> xU ika tisaqfisg Nghdw tpspkG tpisT mikggpid cUthfFfpdwJ. ,it Vhp jlLfs (Airy's discs) vd

mioffggLfpdwd. ngUkghyhd xspapay fUtpfs tllg gpsTfs %ykhfNt gpkgqfis cUthfFfpdwd. tllg gpstpwfhd ikag ngUkk myyJ Kjy rpWkjjpwfhd epgejid.

$$a\sin q = 1.22l$$

,qF 1.22 vdw vzkjpgG› tlljJis xdwpdhy VwgLk ikag ngUkk myyJ Kjy rpWkjjpd NfhitfF chpaJ. ,jid tpsfFtjwF cah fzpjk Njitggltjhy ,jidggwwp cah tFgGfspy gbffyhk.

rpwpa Nfhzqf SfF› $\sin\theta \approx \theta$

$a\theta = 1.22\lambda$

rkdghlbid NkYk khwwpaikfFk NghJ›

$$q = \frac{1.22l}{a}$$

tbtpaypd gb› $q = \frac{r_o}{f}$

gpujpaplL khwwpaikff›

$$r_0 = \frac{1.22l\, f}{a}$$

vLjJffhlbwF› mUfUNf mikeJss ,U Gsspy %yqfs mtwwpd gpkgqfisj jpiuapy cUthfFfpdwd. xdwpd tpsikG tpisT tbtikgG (pattern) mLjjjd tbtikgGld nghUejp xU kqfyhd myyJ gphpffggllhj gpkgjij cUthfFk jukhd myyJ edF gphpffggll gpkgjij cUthff ,U Gsspy %yqfspd tpsikG tpisT tbtikgGfs xdwd Nky xdW nghUejhj tifapy itffggl NtzLk.

,uhNyapd epgejidggb› xU gpkgjpYss ,U mLjjLjj GsspfSs xU Gsspapila tpsikG tpisT ikag ngUkKk kwwjd Kjy rpWkKk nghUejp tejhNyh (myyJ) mjwF kWjiyahf ,UejhNyh mgGsspfs rwNw gphpffggll Gsspfs (Just resolved) vdggLk mjhtJ ,U ikag ngUkqfSfF ,ilggll njhiyT Fiwejglrk r_o Mf ,Uff NtzLk ,kkjpgG ,lkrhh gupgG vdTk njhlhGila Nfhz kjpgG θ Nfhzkrhh gphpgG vdTk mioffggLfpdwd.

xU nghUspd kJ kpf mUfUNfAss xU GsspfisNah myyJ mUfUNf csspy nghUsfisNah gphpjJg ghhfFk (myyJ) NtWgLjjpg ghhfFk jpwikfF xspapay fUtpapd gphpjpwd vdW ngah. nghJthfg gphpgG vdw nrhy cUthFk gpkgjjpd jujijAk› gphpjpwd vdgJ xspapay fUtpapd gphpjjpwpAk jpwikiaAk FwpfFk. gphpgG kwWk gphpjpwd ,itapuzLk xdwd jiyfo kwnwhdW MFk.

xspapd; jstpisT (Polarisation):
FWffiyfs nelliyfs ,itapuzLNk FWfflL tpisT kwWk tpsikG tpisit VwgLjJfpdwd. xypmiyfs $l ,ttpuzL tpisTfisAk VwgLjJfpdwd. Mdhy xspapd FWffiyg gzG jstpistpd %yk epWtggLfpwJ. xspmiy guTk jpirfFr nrqFjjhf csspxU Fwpggll jpirapy xspapd mjphTfis (kpdGyk myyJ fhejgGy ntflh) mDkjpfFk epforrpfF xspapd jstpisT vdW ngah. ,ej myfpy GhpeJnfhstjwF vspikahf ,Uff› kpdGyk klLNk vLjJfnfhssgglLssJ.

KOtJk; jstpis milej xsp (Plane Polarized light)
miyguTk jpirfFr nrqFjjhf csspjsjjpy› midjJ jpirfspYk mjphTfisg FWffiyiaNa jstpistww xsp vdgh jstpistww xspapd midjJ mjphTfSk xU nrqFjJf $Wfshfg gphpjJf fhllgglLssd. miyguTk jpirfFf nrqFjjhf csspjsjjpy xU jpirapy klLk mjphTfisg

ngwWss xsp miy› jstpisT milej xsp myyJ KOtJk jstpisT milej xsp vd mioffggLfpwJ.

jstpistww kwWk KotJk jstpisT milej xsp miyfs kpdGy ntflhfisf nfhzLss jsjjpwF (ABCD) mjphTjjsk vdW ngah. xspffwiwiaf nfhzLss› mjphTjjsjjpwFr nrqFjjhf css jsjjpwF (EFGH) jstpisTjjsk vdW ngah. ,ttpU jsqfSNk xspguTk jpirapidf nfhzbUffk.

jstpisT milej kwWk jstpisT milahj xspffwiwfspd rpy gzGfs tpthpffgglLssd.

jstpisT Mf;Fk; Elgq;fs; (Polarisation techniques)

jstpistww xspapypUeJ› gyNtW Elgqfisg gadgLjjpj jstpisT milej xspiag ngwyhk. ,qF› gpdtUk ehdF Kiwfisggwwp klLk gbffyhk.

1. njhpT clfthjy %yk jstpisT Mffk
2. vjpnuhspggpd %yk jstpisT Mffk
3. ,ulil xsptpyfypd %yk jstpisT Mffk
4. xsprrpjwy %yk jstpisT Mffk

Njhe;njLf;fggl;l clf;fthjy; (myyJ) njhpT clf;fthjy; %yk; jstpisT Mf;fk;
(Polarisation by selective absorption)
njhpT clfthjy vdgJ nghUspd xU gzghFk. Fwpggpll xUqfikT jpirfF ,izahf css jsjjpy klLk kpdGy mjphTfisg ngwWss xsp miyfisj jd topNa nryy mDkjpjJk› kww midjJ xsp mjphTfisAk clftUk nghUspd ,ggzgpwFj njhpT clfthjy vdW ngah. NghyuhaLfs (Polaroids) myyJ jstpisT Mffpfs vdgit› nkyypa tzpf ujpahfg gadgLk jfLfshFk. ,it› njhpT clfthjy gzig mbggilahff nfhzL› mjpfr nrwpT nfhzl KOtJk jstpisT milej xsp miyfis cUthfFfpdwd. njhpT clfthjiy› ,Utzzj jdik (dichroism) vdWk mioffyhk.

1932 ,y mnkhpff mwptpay mwpQh vltpd yhzl (Edwin Land) vdgth jfL tbtpyhd jstpisT Mffpfis cUthffpdhh. ,awifapy fpilfFk jstpisT Mffp lhkiyd (Tourmaline) MFk. jstpisT Mffpfisr nrawifahfTk cUthffyhk. rpwpa Crp tbtpyhd Fapdpd mNahNlhryNgl (Quinine iodosulphate) gbfqfs› xspiaj jstpisT MfFk gzgpidg ngwWssd vdf fzlwpagglLssJ. ,uzL xspGFk gpsh]bf jfLfSfF eLNt mjpf vzzpfifapy ,ggbfqfspd mrRfs xdWfnfhdW ,izahf cssthW mikjJ› mjidg Nghyuhalhfg Myf`hy (Polyvinyl alcohol) nkyNyLfisg gadgLjjpg NghyuhaLfs cUthffggLfpdwd. ,it› mjpf xspfljJk jdik nfhzl epwkww gbfqfshFk. NkYk ,it rpwej Kiwapy xspia› jstpisT milar nrafpdwd.

jstpisT Mf;fp kwWk; jstpisT Ma;tp (Polarisar and Analyser)

jistpisT mww xspffwiw xdiwf fUJNthk. xspguTk jpirfFr nrqfjjhf css midjJj jpirfspYk jstpistww

jstpisT milej kwWk; jstpisT milahj xspf;fwiwfspd; rpy gz;Gfs;

t.vz;	jstpisT milej xsp	jstpisT milahj xsp
1.	xspffjphguTk jpirfFr nrqFjjhf css xNu xU	xspffjph guTk jpirfFr nrqFjjhf css midjJ

	jsjjy klLk kdGy ntflhfs mjhTfisg ngwwUfFk	jirfsYk kdGy ntflhfsd mjhTfs gqflgglbUfFk.
2.	xsffjh guTk jiriag nghWjJ rkrruwwJ	xsffjh guTk jiriag nghWjJ rkrruhdJ
3.	jstistT Mffifisg gadgLjjy jstistT milahj xsaiyUeJ, ttifahd xs ngwggLfwJ.	kughd xs%yqfsiyUeJ, ttifahd xs filffwJ

xsffwiw mjhTfisg ngwwUfFk. ,ffwiw P_1 vdw NghyuhaL toNa nryYkNghJ xU Fwggll jsjjy klLk mjhTfs mDkjffggLfdwd. Nghyuhaby ,Uej ntsNaWk xsffwiw kwnwhU P_2 vdw NghyuhaL toNa nrYjjggLfwJ. xsffjiu mrrhff nfhzL P_2 Nghyuhailr RowWkNghJ P_2 Nghyuhabd xU Fwggll eiyaiy xsrnrwT ngUkkhfwJ. ,ej eiyaiyUeJ Nghyuhail NkYk RowWkNghJ xsrnrwT Fiwa Mukgij J, P_2 NghyuhaL 90° I milAk NghJ xsrnrwT KwwYk kiweJ tLfwJ. kzLk *P_2* Nghyuhailr RowWk NghJ kzLk xs Njhdw Mukgij J gbggbahf xsrnrwT mjfhjJ 180° Rowraiy ngUk xsrnrwT filffwJ. *P_1* Nghyuhaby ,UeJ ntsNawa xs KOtJk jstistT milej xsahFk. jd toNa ghAk jstistww xsia, KOtJk jstistT milej xsahf khwWk NghyuhaLfFj (,qF *P_1*) jstistT Mffi vdW ngah. jd toNa ghAk xsia, jstistT milej xsah? myyJ jstistT milahj xsah? vd MaT nraAk NghyuhaLfF (,qF *P_2*) jstistT Mati vdWngah.

jstistT mww xsaid nrwT *(I)* vdiy, jstistT milej xsaid nrwT $\left(\frac{1}{2}\right)$ thf ,UfFk. kwnwhU gqF xsrnrwthdJ, jstistT Mffiahy jLffggLfwJ.

KOtJk kwWk gFji jstistT milej xsi

jstistT Matid Roaiy UeJ 90° tiu xtnthUKiw RowWk NghJk, xsrnrwT RofFk ngUkjjwFk ,ilaiy khwwkilejhy, mtnthsia KOtJk jstistT milej xsi vd mioffyhk. ,jwFf fhuzk Xh mrriy mjhTfs mDkjffggLfdwd. ,ttrRfFr nrqFjjhf css mrriy mjhTfs KwwYk jLffggLfdwd. ,jwF khwhf, jstistT Matiad xtnthU 90° RowrfFk xsrnrwT ngUkjjwFk rWkjjwFk (Rornrwt myy) ,ilaiy khwwkilejhy mej xsiag gFji jstistT milej xsi vd mioffyhk. ,jwFf fhuzk Fwggll mrriy xsi KwwYk jLffgglhjNj MFk. vdNt, Fiwej nrwT xsi NjhdWfwJ.

khy]; (Malus) tiji

I_o nrwT nfhzl KOtJk jstistT milej xs, jstistT Matiaiy tiOeJ *I* nrwT nfhzl xsahf jstistT MatiaiyUeJ ntsNaWkNghJ, mjd nrwT jstistT Mffi kwWk jstistT Matiad guT jsqfSfF ,ilNa css Nfhzjjid θ nfhird kjggd ,UkbfF Nehtfjjjiy ,UfFk. ,jwF khy] tiji vdW ngah. 1809 ,y guQR mwQh E.N. khy] ,jidffzlwejhh.

$$I = I_o \cos^2\theta$$

khy] tijaid e&gzk gdtUkhW, jstistT Mffi kwWk jstistT Matiad jsqfs fhlbAssthW xdWfnfhdW θ Nfhzjjiy rhaeJssd vdffUJf. jstistT Mffiaiy UeJ ntsNaWk xsaid kidGy ntflhid nrwit I_o vdTk.

mjd trir *a* vdTk nfhsf. gLk xsiad trR *a* ,uzL $Wfisg ngwWssJ mit *a cos θ* kwWk *a sin θ* MFk. ,it KiwNa jstisT Matiad guT mrriwF (axis of transmission) ,izahfTk› nrqFjjhfTk cssd.

a cos $W θ klLk jstisT Matiad toiahf ntsiNaWk. jstisT Matiad toiahf ntsiNaWk xsiad nrwT› jstisT Matiad toiahf ntsiNaWk trRf$wid ,UkbfF Nehtfijjjy ,UfFk.

$$I \propto (\cos\theta)^2$$
$$I = k(a\cos\theta)^2$$

,qF *k* vdgJ tifjkhwiy
$$I = ka^2\cos^2\theta$$
$$I = I_o\cos^2\theta$$

,qF› $I_o = ka^2$ vdgJ› jstisT Matiad toiahf ntsiNaWk xsiad ngUk xsirnrwithFk.

riwgG NehTfs; gid tUkhW.

NehT (i) θ = 90° vdiy› cos 0° = 1, vdNt I = I_o

jstisT Mffi kwWk jstisT Matiad guT mrRfs jirfs xdWfnfhdW ,izahf cssNghJ› jstisT Matiad toiahf ntsiNaWk xsiad nrwTk› jstisT Mffiad kJ tiOk xsiad nrwTk rkkhFk.

NehT (ii) θ = 90° vdiy cos 90° = 0 vdNt› I = 0
jstisT Mffi kwWk jstisT Matiad guT mrRfs xdWfnfhdW nrqFjjhf css NghJ› jstisT Matiad toiahf ntsiNaWk xsiad nrwT RoiahFk.

khy]; tiji
Nghyhuha;Lfsid; gad;fs;

1. NghyuhaLfs› fz $Rtijj jLfFk fz zhbfshfTk› Gifgglffutifsiy xsitbgghdhfTk NkYk ntaiy fhgGf fz zhbfsiYk gutyhf gadgLfidwd.

2. Kgghikhz jiuggllffhlrifis mjhtJ N`hNyhfiuhgia (holograph) cUthff NghyuhaLfs gadgLfidwd.

3. gioa vznza Xtiaqfsiy eiwqfis NtWgLjji miwa NghyuhaLfs gadgLfidwd.

4. NghyuhaLfs xsij jifT gFgghatiy (Optical stress analysis) gadgLfidwd.

5. [ddy fz zhbfsiy NghyuhaLfisg gadgLjji miwaid csNs tUk xsiaid nrwitf flLggLjjyhk.

6. jstistilej Nyrh fwiw› CriKid NghdW nrayglL› FWejfLfisg (CDs) gbff myyJ mtwwiy nrajifisg gjiT nraa gadgLfidwd.

7. jut gbfj jiuay (LCD)› jstisT milej xsi gadgLjjggLfwJ.

vjnuhsiggid %yk; jstisT Mf;fk;

KOtJk jstisT milej xsia cUthffg gadgLk kf vsaKiw vjnuhsigG MFk. XY vdw vjnuhsifFk fzzhbg guggid kJ› AB vdw jstisT mww xsiffwiw xdW tiOfwJ vdffUJf. ,ej xsiahdJ vjnuhsigG kwWk tiyfy Mfia ,uzilAk milfwJ. jstisT milahj xsiay vjnuhsigGj jsjjwF ,izahf css mjhTfSk (GsssfshY FwffggllLssd) ,izahf ,yyhj mjhTfSk (mkGfFwfshy FwffggllLssd) cssd. xU Fwggll gLNfhzjjiy vjnuhsiffggll xsi KOtJk jstisT mileJk tiyfyilej xsi gFji jstisT mileJk fhzggLfidwd. Vnddiy› jsjjwF ,izahd mjhTfs vjnuhsigG milfidwd. kwwit tiyfyilfidwd. gFji jstisT milej xsiay riy ,izahd mjhTfSk fhzggLfidwd. vejf Fwggll gLNfhz kjiggwF vjnuhsigG milej fjh KwwYk jstisT milejNjh› mejg gLNfhzNk jstisTf Nfhzk MFk i_p.

GU]Ih; tiji

NkYk gphlb~ mwQh rh Nltil GU]lh (Sir David Brewster), jstisTf Nfhzjjiy vjnuhsigG milej kwWk xsitiyfy milej xsiffjhfs xdWfnfhdW nrqFjJ vdf fzlwejhh. i_p vdgJ jstisTg gLNfhzk vdTk› r_p vdgJ ,jwfhd xsitiyF Nfhzk vdTk fUjdhy› tbtiay gb›

$$r_p = 90° - i_p$$

]ndy tijaiyiUeJ xsiGFk Clfjjid xsitiyfy vz

xsitiyfy vz

$$\frac{\sin i_p}{\sin r_p} = n$$

,qF n vdgJ xsitiyfy vz zhFk.

,UeJ r_p aid kjigig gujiaiLk NghJ gidtUk rkdghL filfFk.

$$\frac{\sin i_p}{\sin(90° - i_p)} = \frac{\sin i_p}{\cos i_p} = n$$

$$\tan i_p = n$$

,jnjhlhGfF GU]lh tij vdW ngah. GU]lh tijaidgb› xsiGFk Clfjjid jstisTf Nfhzjjid NlQrdl kjigG› mej Clfjjid xsitiyfy vz zwFr rkkhFk. jstisTf Nfhzk myyJ GU]lh Nfhzjjid kjigG› xsi GFk Clfjjid jdik rhhejJ.

jl;lLf;Ffs; (Pile of Plates)

gFji jstisT milej xsia KOtJk jstisT milej xsahf khwWjiy G&]lh tijaid mbggilaiy jllUfF nrafwJ. ,jiy xtnthdWk filkllijJld *90 – i_p* Nfhzjjiy cssthW gy fzzhb jlLfs xdwdgid xdwhf mLffi itffgglLssd ,iz xsiffjh ,jjllLfsid kJ i_p Nfhzjjiy tiOtij ,ttikgG cWji nrafwJ. mLjjLjj jlLfsid toNa ,ej jstisT mww xsi nryYkNghJ› tiyfyilej xsiay guggwF ,izahfAss mjhTfs

mLjjLjj jlLfspy NkYk vjpuhspgG milfpdwd. ,jd %yk; vjpuhspgG milej fjpUk tpyfyilej fjpUk KOtJk jstpisT milfpdwd.

,ulil xsp tpyfypd; %yk; jstpisT Mf;fk;

vuh]k] ghhNjhypd] (Erasmus Bartholin us) vdw lrR ,awgpay mwpQh; jstpistww xspffwiw fhyirl gbfjjpd kJ tpOk NghJ ,uzL xsptpyfy fjphfshfg gphpif milfpwJ vdf fzlwejhh. vdNt; ,uzL gpkgqfs NjhdWfpdwd. ,ej epforrpfF ,ulil xsptpyfy vdW ngah. Fthhl]; ikffh Nghdw kww nghUsfspYk ,ggzG fhzggLfpwJ.

Gssp xdwpid fhyirl gbfjjpd topNa nrqfjjha ghhfFkNghJ ,uzL gpkgqfs NjhdWk; gbfjijr RowWk NghJ xU gpkgk epiyahfTk kwnwhU gpkgk; epiyahd gpkgjij RwwpAk tUfpwJ. epiyahf css gpkgk O, xsptpyfy tpjpfSfF clgLk rhjhuz fjphpdhy VwgLfpwJ. kwnwhU gpkgk E, xyptpyfy tpjpfSfF clglhj mrhjhuz fjphpdhy vwgLfpwJ. ,ej mrhjhuz xsp ffjph KOtJk jstpisT milej fjph vdf fzlwpagglLssJ. ,ulil xsptpyfy VwgLk gbfjjpd csNs rhjhuz ffjph midjJj jpirfspYk xNu jpirNtfjjpy nryfpwJ. Mdhy; mrhjhuz ffjph xtnthU jpirapYk nttNtW jpirNtfqfspy nryfpwJ. gbfjjpd csNs css; Gssp xsp %yk xdW rhjhuz ffjpUfFf Nfhsf miyKfgigAk; mrhjhuz fjpUfF estll miyKfgigAk cUthfFk. gbfjjpd csNs xU Fwpggpll jpiray ,ttpuzL fjphfSk xNu jpirNtfjjpy nryfpdwd. mejj jpirfF xspapay mrR vdW ngah. xspapay mrrpy; ,uzL fjphfSk xNu xsptpyfy vzizg ngwwpUfFk. NkYk; ,ej mrrpy ,ulil xsptpyfYk VwglhJ.

xspapay; nraygGhpAk; gbfqfspd; tiffs;

fhyirl; Fthhl]; lhkiyd kwWk gdpfflb Nghdw gbfqfs xNu xU xspapay mrirg ngwWssd. vdNt; mit XurRggbfqfs vdW mioffggLfpdwd.

ikffh; G~guhfk (Topaz) nrypidl; muhNfhidl Nghdw gbfqfs ,uzL xspapay mrRfisg ngwWssd. vdNt mit <urRggbfqfs vdW mioffggLfpdwd.

epNfhy; gl;lfk;

epNfhy (Nicol) gllfk; kww xspapay fUtpfSld ,izeJ KOtJk jstpisT milej xspia cUthffTk; MaT nraJ ghhffTk gadgLfpwJ. epNfhy gllfk ,ulil xsptpyfy epfotpd mbggilapy nraygLfpwJ. ,jid 1828 ,y tpyypak epNfhy vdw mwpQH cUthffpdhh.

mfyjijgNghdW %dWklqF esk nfhzl fhyirl gbfjjpdhy gbfjjpd Nfhzqfs 72° kwWk 108° cssthW %iytpllijjpd topNa ,uzL JzLfshf ntllggLfpwJ ,ttpuzL JzLfSk fdlh ghyrk vdw xspGFk rpnkzl nfhzL xdWld xdW xllggLfpdwd.

xwiw epw xsp%yk xdwpypUeJ tUk jstpistww xsp epNfhy gllfjjpd kJ tpOfpwJ vdffUJf. ,ej xsp ,ulil xsptpyfy mileJ rhjhuz kwWk mrhjhuz fjphfshfg gphpif mileJ nttNtW jpirNtfqfspy nryfpdwd. rhjhuz xspfFg (xwiw epw Nrhba xsp) gbfjjpd xsptpyfy vz 1.658; mrhjhuz xspfF xsptpyfy vz 1.486. ,Nj miyesk nfhzl xspfFf fdlh ghyrjjpd xsptpyfy vz 1.523.

fhdlh ghyrjjpdhy; rhjhuz xsp KO mf vjpuhspgG mileJ; gbfjjpd kwnwhU Kfk topahf ntspNawhky jLffggLfpwJ. KO jstpisT milej mrhjhuz xsp klLk gbfjjpd topahf ntspNaWfpwJ.

eNfhy; gbfj;jd; FiwghLfs;

1. mstpy nghpa> Fiwghlww fhyirl gbfqfs fpilggJ mhpJ. vdNt> eNfhy gbfjjpd tpiy kpf mjpfk
2. mrhjhuzf fjph rhaej epiyapy gbfjjpd topNa nrytjhy> gbfjjpypUeJ ntspNaWk KO jstpisT milej xspffjph vgnghOJk xU gffkhf tpyfy milejpUfFk.
3. xU Fwpggpll tukgpy klLNk ,jidg ghhff KbAk.
4. eNfhy gllfjjpypUeJ ntspNaWk xspffjph> ruhf Kojstpist milejpUffhJ.

xspr; rpjwypd; %yk; jstpisT Mf;fk;

tspkzly %yf$Wfshy #hpa xsp rpjwyilAk NghJ> ,ej %yf$Wfspy css vyfluhdfs #hpa xspapYss kpdGyjjpd mjphtilAk $Wfspd ghjpgGfF clgLfpdwd #hpa xsp jstpisT mww xsp vdgjhy> mJ midjJ jpirfspYk mjphTfis cUthfFfpdwJ. ,ej mjphTWk vyfluhdfs mtwwpd mjphTfSfF nrqFjjhd jpirapy ghhfifapy> ghhfFk jpirfF nrqFjjhd jpirapy klLNk Mwwiy ntspNawWfpdwd. Mathsh xUth #hpa xspia mJ guTk jpirfF nrqFjjhd jpirapy ghhfifapy> ghhfFk jpirfF nrqFjjhd jpirapy mjphTWk vyfluhdfshy cUthffggLk fjphfs klLNk mtiu tejilAk. Mathsiu tejilAk xsp KotJk jstpisT milej xsp vdgJ ,jypUej njhpfpwJ.

xspapay; fUtpfs; (Optical Instruments)

ehk mdwhl thotpy gyNtW xspapay fUtpfisg gadgLjJfpdNwhk. mtwWs EzNzhff> njhiyNehff> epwkhiykhdp kwWk kdpj tpofs

vspa EzNzhf;fp

vspa EzNzhffp vdgJ xU nghUspd Neuhd cUgngUffk nraaggll kha gpkgjijg ngw cjTk Fiwej Ftpajp}uk (f) nfhzl xU cUgngUffk (FtpfFk) nydR MFk. vdNt> nydrpd xU gffjjpd Ftpajp}ujjpwF clgll njhiytpwFs nghUs itffgglL mLjj gffjjpd topahf mijg ghhff NtzLk kpfTk mUfhikapy css vejg Gsspt tiuapy fzzhy njspthff fhz ,aYNkh mJ mzikgGsspt vdTk> kpfTk njhiytpy css vejg Gsspt tiuapy njspthff fhz ,aYNkh mJ NraikgGsspt vdTk mioffggLfpwJ. eykhd fzzpd mzikgGsspapd njhiyT *25 cm (D* vdW FwpffggLk)> NraikgGsspt <wyhj njhiytpy ,UfFk.

mz;ikgGs;spt Ftpaggl;Jjy;

gpkgkhdJ mzikgGsspapy (mjhtJ> 25 cm) cUthFk NghJ fz kpff Fiwej mst rpukjjpwF csshFk. mzikgGsspapd njhiyT njspTW fhlrapd krrpW njhiyT vdTk mioffggLfpwJ. nghUspd njhiyT *f* I tplf FiwthfTk gpkgjjpd njhiyT mzikgGsspt D MfTk ,Uff NtzLk. ,ej nydrpd cUgngUffk> $m = \frac{v}{u}$

,U njhiyTfSNk nydrpwF ,lJ gffkhf mstplggLtjhy> $v = -D$ vdTk $u = -u$ vdTk gpujpapl $m = \frac{-D}{-u}$

$$m = \frac{-D}{-u}$$

cUgngUffk *m, u,* Ftpalj}uk %yKk vOjyhk.
nydR rkdghlhd mjhtJ

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$ mjhtJ $m = \frac{v}{u}$ lg gpujpapl› $m = 1 - \frac{v}{f}$

$v = -D$ vdg gpujpapl›

$$m = 1 + \frac{D}{f}$$

,JNt mzikg Gsspl Ftpaggljjypd cUgngUffk MFk.

,ayGepiy Ftpaggljjy;

,ayG epiy Ftpaggljjy - nghUspd gpkgk <hpyyhj njhiytpy NjhdWk. ,ej epiyapy fzfSfF vttpj rpukKk ,dwpg gpkgjij trjpahfg ghhff KbAk.

,ayGepiy Ftpaggljjy gpkgk <hpyyhj njhiytpy csspl NghJ VwgLk cUgngUffjijj jwNghJ fhzyhk. gpkgjjpwFk› nghUSfFk csspl tpfpjk æ $m = \frac{h'}{h}$ ö cUgngUffjijf nfhLfFk. <hpyyhj njhiytpy kwWk <hpyyh mstpy VwgLk gpkgjjpwfhd eilKiwj njhlhgpid ngw ,ayhJ. vdNt› ehk Nfhz cUgngUffjij ,qFg gadgLjjyhk. nydrpd cjtpahy ghhffggLk gpkgk VwgLjjpaf NfhzjjpwFk θ_i nydrpd cjtpapdwp ntWk fzfspdhy ghhffggLk nghUs VwgLjjpaf NfhzjjpwFk θ_o csspl tpfpjjjpwF› Nfhz cUgngUffk vdW ngah.

$$m = \frac{q_i}{q_o}$$

ntWk fzfspdhy ghhffggLk nghUSfF›

$$\tan q_o » q_o = \frac{h}{D}$$

nydrpd cjtpahy ghhffggLk gpkgjjpwF

$$\tan q_i » q_i = \frac{h}{f}$$

Nfhz cUgngUffk›

$$m = \frac{q_i}{q_0} = \frac{h/f}{h/D}$$

$$m = \frac{D}{f}$$

Nkwfzl rkdghL› ,ayGepiy FtpaggLjJjYffhd cUgngUffjijf nfhLfFk. mzikgGsspl FtpaggLjJjYffhd cUgngUffjijtpl› ,ayGepiy FtpaggLjJjYffhd cUgngUffk FiwthFk. mzikg Gsspapy Ftpaggljjggll gpkgjijg ghhggijtpl› ,ayGepiy FtpaggLjJtjpdhy VwgLk gpkgjijg ghhggJ fzfSfF vspjhFk *D/f* ,d nghpa kjpgGfSfF› ,uzL cUgngUffqfSfF ,ilNa csspl NtWghL kpfTk FiweJtpLfpdwJ.

Ez;Nzhf;fpaid; ghhjpwd;

EzNzhff;iaf nfhzL nghUis cwWNehfFtjd %yk mgnghUs njhlhghd t;tuqfis mw;ayhk. xU eyy EzNzhff;ahdJ nghUis cUgngUffk nratJ klLkyyhky mgnghUs;y r;Wkj njhiyt;y ($d_{r;Wkk}$) g;h;jJ itffggll ,U Gss;fisg g;h;jjw;eJ fhllTk Ntzlk. ,qF $d_{r;Wkk}$ vdgJ g;h;gG vdTk mjd jiyfo; g;h;jw;d vdTk mw;aggLk.

,lkrhh g;h;gig (ikag ngUkj;jd Muk)

Vwfdnt ghhjjgb› $r_o = \dfrac{1.22\lambda f}{a}$

xU EzNzhff;a;y› nghUs;d njhiyT vdgJ Ft;ajJ}ujij *(f)* t;l rwW mj;fkhf ,UfFk NkYk g;kgj;jd njhiyT *v* y *f*fFg gj;yhf *v* vdW khww›

$$r_o = \frac{1.22\lambda v}{a}$$

$d_{r;Wkk}$ vdgJ nghUs;d kJss ,U Gss;fSfF ,ilggll njhiyT vd;y› cUgngUffk *m*

$$m = \frac{r_o}{d_{\min}}$$

$$d_{\min} = \frac{r_o}{m} = \frac{1.22\lambda v}{am} = \frac{1.22\lambda v}{a(v/u)} = \frac{1.22\lambda u}{a} \quad [\because m = v/u]$$

$$d_{\min} = \frac{1.22\lambda f}{a} \qquad [\because u = f]$$

nghUs css gffj;jy›

$$2\tan\beta \approx 2\sin\beta = \frac{a}{f} \quad \therefore [a = f2\sin\beta]$$

$$d_{\min} = \frac{1.22\lambda}{2\sin\beta}$$

r;Wkj njhiyT (d_{min}) jj;jd kj;gig NkYk Fiwggjw;F› EzNzhff;a;d nghUsUF nydi] mj;f xs;t;yfy vz *n* nfhzl vznza e;uggggll nfhsfyd;y %ofitjJ› xs;a;d ghijia mj;fh;ff Ntzlk.

$$d_{\min} = \frac{1.22\lambda}{2n\sin\beta}$$

,J Nghdw nghUsUF nyd]fSfF vznzaa;y %ofitffggll nghUsUF nyd] vdW ngah. $n\sin\beta$ gjj;jw;F vz z;ay Jis NA vdW ngah.

$$d_{\min} = \frac{1.22\lambda}{2(NA)}$$

EzNzhff;a;d gu;j;jwd R_M vdgJ›

$$R_M = \frac{1}{R_{\min}} = \frac{2(NA)}{1.22\lambda} = \frac{2n\sin\beta}{1.22\lambda}$$

njhiyNehf;fj;a;d; g;h;j;jwd;

Vwfdnt tUt;ffggll fi;ilffgngWk ,lkrhh g;hggd jiyfo; njhiyNehff;a;d gu;j;jwd vdggLfwJ.

njhiyNehf;fj;a;d; gu;j;jwd;

Vwfd Nt tUtpffggll rkd fpilffgngWk ,lkrhh gphpggpd jiyfopnjhiyNehffpapd gupjpwd vdggLfpwJ.

$$R_T = \frac{1}{r_0} = \frac{a}{1.22\lambda f}$$

$lL EzNzhfpfp (Compound microscope)

$lL EzNzhffpapd mikgG fhllggllLssJ. nghUSfF mUNf css nydRfFg nghUsUF nyd] vdW ngah. ,ej nyd] nghUspd nkaahd› jiyfohffggll kwWk cUngnUffggll gpkgjijj NjhwWtpfFk. ,ggpkgk› ,uzlhtJ nydrhd fzzUF nydRfF nghUshfr nraygLfpwJ. fzzUF nydRfF nghUshfr nraygLfpwJ. fzzUF nyd] Xh vspa EzNzhffp NghdW nrayglL ,Wjpahfg nghpjhffggll khagpkgjijj NjhwWtpffpwJ. nghUsUF nydrpdhy NjhwWtpffggll jiyfohd Kjy gpkgk› fzzUF nydRfF neUffkhf› Mdhy mjd Ftpaggugg pwFs ,UfFkgb rhpnraAk NghJ› ,Wjp gpkgk fpllijll <hpyyhj njhiytpy myyJ mzikg Gsspapy NjhdWk. ,Wjpgpkgk czikahd nghUisgnghUjJj jpiyfohff fpilfFk.

$lL EzNzhfpfpapd cUgngUffk

fjph xspgglijjpyUeJ› nghUsUF nydrpd gfffthlL cUgngUffk› gpdtUkhW›

$m_o = \frac{h'}{h}$,UeJ $\tan b = \frac{h}{f_o} = \frac{h'}{L}$

$$\frac{h'}{h} = \frac{L}{f_o}$$

$$m_o = \frac{L}{f_o}$$

,qF› *L* vdgJ fzzUF nydrpd Kjy Ftpagpssp fFk› nghUsUF nydrpd ,uzlhk Ftpagpssp fFk ,ilNa css njhiythFk. ,jwFf $lL EzNzhffpapd Foypd esk *(L)* vdW ngah. NkYk f_o kwWk f_e ,uzLk *(L)* I tplf Fiwthfjjhd ,UfFk.

,Wjp gpkgk› mzikgGsspapy mikejhy› fzzUF nydrpd cUgngUffk m_e gpdtUkhW

$$m_e = 1 + \frac{D}{f_e}$$

mzikgGssp Ftpaggljjypd nkhjj cUgngUffk (*m*) gpdtUkhW

$$m = m_o m_e = \left(\frac{L}{f_o}\right)\left(1 + \frac{D}{f_e}\right)$$

,Wjpgpkgk <hpyyhj njhiytpy mikejhy (,ayGepiy Ftpaggljjy)› fzzUF nydrpd cUgngUffk m_e gpdtUkhW

$$m_e = \frac{D}{f_e}$$

,ayGepiy Ftpaggljjypy VwgLk nkhjj cUgngUffk *m* gpdtUkhW fpilfFk›

$$m = m_o m_e = \left(\frac{L}{f_o}\right)\left(\frac{D}{f_e}\right)$$

thdpay njhiyNehffpapd cUgngUffk

gpkgk VwgLjJk Nfhzjjpwfk β, nghUs Kjdik mrRld VwgLjJk Nfhzjjpwfk *a* css tpfpjNk thdpay njhiyNehffpapd cUgngUffk (*m*) MFk.

$$m = \frac{b}{a}$$

gljjpypUeJ $a = \frac{h}{f_o}; b = \frac{h}{f_e}$

$$m = \frac{f_o}{f_e}$$

thdpay njhiyNehffpapd Njhuha esk›

$$L = f_o + f_e$$

vjpnuhspgGj; njhiyNehf;fp (Reflecting telescope)

nghpa mstpyhd kwWk xspapay FiwghLfsww gpkgqfisj NjhwWtpfFk nydRfis cUthfFtJ kpfTk fbdkhdJ kwWk nghUlnryT kpffJ MFk. etd njhiyNehffpfspy nghUsUF tpyiyfshf nyd]fSfF khwwhf Fop Mbfs gadgLfpdwd.

nghUsUF tpyiyfshf Fop Mb nraygLk njhiyNehffpfF vjpnuhspgG njhiyNehffp vdW ngah. ,it $Ljy rpggpidg ngwWssd. Mbapy xNu xU gugpgpid klLk nkUNfwwpg gsgsgghf itjJf nfhstJ NghJkhdjhFk. Mdhy› nyd]py ,U gugGfSfFk mttpjk nraa NtzLk. nyd]fs mtwwpd tpspkGfspy klLNk jhqfp epWjjggLfpdwd. Mdhy› Mbfisg gadgLjJkNghJ mtwwpd gpdgffk KOtijAk› jhqfpggpbggjwFg gadgLjjyhk. ,Ugg pDk› vjpnuhspgG njhiyNehffpapy xU FiwghL cssJ. mjhtJ› nghUsUF Mb njhiyNehffpf Foypd csNsNa xsp FtpffggLfpwJ. fzzUF nydrpid Foypd csNs nghUjjp gpkgjijf fhzgJ rpukkhFk. ,fFiwghL jwNghJ epthjjp nraaggLlssJ. mjhtJ ,uzlhtJ Ftp Mb xdwpidg gadgLjjp Foypd csNs Ftpaggljjggk xspia› Foypd ntspggffkhf nfhzLteJ gpkgjijf fhzyhk.

epwkhiykhdp (Spectrometer)

gyNtW xsp%yqfspypUeJ tUk epwkhiyfis MuhaTk› nghUsfspd xyptpyfy vzfisf fzffplTk epwkhiykhdpfs gadgLfpdwd. epwkhiykhdp xdW mbggilapy epwkhiykhdp %dW gFjpfisf nfhzLssJ. mit KiwNa ,izahff› Kgglf Nkil kwWk njhiyNehffp MFk.

,izahf;fp

,iz xspffwiwia cUthfFk mikgNg ,izahffp MFk. ,J xU Ftpnydirak xsp%yjij Nehffpathw css› khwwf$ba tpgT cila nrqFjJg gpsitAk nfhzlJ. gpstpd njhiytpidr rhpnraJ nydrpd Ftpajjpy epiyepWjj KbAk. Kgglfjjpd mbghfjJld ,izahffp cWjpahfg nghUjjggLlssJ.

Kgpgl;lf Nkil

Kgglfk› fwwzp Nghdwtwiwg nghUjJtjwF KgglfNkil gadgLfpwJ. %dW rhp nraAk jpUFfSld mikej ,uzL ,izahd tlltbtj jlLfs Kgglf Nkilapy cssd. RoYk tifapy nghUjjggLlss Kgglf Nkilapd epiyia nthdpah V_1 kwWk V_2 Mfpatwiwf nfhzL mwpayhk. Njitahd caujjpwF Kgglf Nkila cahjJk tifapy mJ mikffgglLssJ.

njhiyNehf;fp

,J thdpay njhiyNehffp tifiar rhhejjhFk. ,jd xU Kidapy FWfFf fkgpfSld mikej fzzUF nydRk> mjd kWKidapy nghUsUF nydRk cssJ. fzzUF nydRfFk nghUsUF nydRfFk ,ilNa css njhiytpidr rhpnraJ> njspthd gpkgjijf FWfFf fkgpapy Njhdw nraayhk.

tlltbt msTNfhy xdW njhiyNehffpAld NrheJ RoYk tifapy nghUjjgglLssJ. njhiyNehffp kwWk KgglfNkil ,uzilAk tpUkGk ,ljjpy epiyepWjJtjwfhf ,uzL Mu jpUF Mzpfs cssd. NkYk> Elgfkhfr rhpnratjwFj njhLNfhL jpUF MzpfSk fhzggLfpdwd.

epwkhiykhdpapy; Nkwnfhs;s Ntz;ba ruikgGfs;

epwkhiykhdpiag gadgLjjp Matpid Nkwnfhs Sk Kdghfg gpdtUk ruikgGfisr nraa NtzLk.

1. **fz;zUF nyd;irr; ruikj;jy;**

   njhiyNehffpia> xspAllggll guggpid Nehffpr Roww> FWfFf fkgpia KdDkgpdDk efhjjpj njspthd gpkgk fzfSfFj njhpAk ,ljjpy mjid epiyepWjj NtzLk.

2. **njhiyNehf;fpiar; ruikj;jy;**
   xspthd gpkgk tpotjwF ,izfjhfisg ngWk tifapy njhiyNehffpiaj njhiytpy css nghUs xdiwf fhZk tifapy epiy epWjj NtzLk.

3. **,izahf;fpiar; ruikj;jy;**

   ,izahffpfF Neuhf njhiyNehffpiaf nfhzL tuTk. FWfFf fkgpapy njspthd gpkgk fpilfFk tiu> ,izahffpapd gpstpwFk> nydRfFk ,ilNa css njhiyitr rhpnraa NtzLk.

4. **Kggl;lf Nkiliar; ruikj;jy;**
   ,urkllk kwWk rhpnraAk jpUfhzpfisg gadgLjjp> Kgglf Nkilia fpilkll epiyapy ,Ujjyhk.

Kggl;lfk; nra;aggl;l nghUspd; xsptpyfy; vz;izf; fhzy;

epwkhiykhdpapd njhlffr ruikgGfisr nraa NtzLk. Kgglfr Nfhzk *A* kwWk rpWk jpirkhwwf Nfhzk *D* Mfpatwiwr fzlwpeJ Kgglfg nghUspd xsptpyfy vzizf fzffplyhk.

1. **Kggl;lff; Nfhzk;** (R)

Kgglfjjpd xsptpyFggffqfs rejpfFk Kid> ,izahffpiag ghhfFk tifapy Kgglf NkilkJ Kgglfk itffggLfpwJ. ,izahffpapd gpsT Nrhba Mtptsffpidf nfhzL (xwiw epw) xspAllggLfpwJ. ,izahffpapypUeJ tUk ,izfjphfs Kgglfjjpd AB kwWk AC gffqfspy tpOeJ vjpnuhspgG milfpdwd.

,ttpuzL mstLfspd NtWghL> njhiyNehffp Rowwgglf Nfhzjijf nfhLfFk. ,fNfhzk Kgglfff Nfhzjjpd ,uzL klqfpwFr rkkhFk. ,kkjpggpy ghjp Kgglfff Nfhzjijf (A) nfhLfFk.

2. rpWkjpirkhwwf; Nfhzk; (D)

,izahffpaypUeJ tUk xsp Kgggllfjjpd Xh xsptpyF gffjjpd kJ tpoeJ› kWgffjjpd topNa xsptpyfy milej xspiaj njhiyNehffpapd topNa ghhfFk tifapy› Kgglllfjjij Nkil kJ nghUjj NtzLk. jwNghJ jpirkhwwfNfhzjjpd kjpgG FiwAk tifapy Kgglllf Nkiliar Roww NtzLk. xU fllj jpy gpkgk Xh ,ljjpy epdW› Kgglllf Nkilia NkYk njhlheJ RowWkNghJ jpUkg MukgpfFk. njhiyNehffpapy ghhjJf nfhzNl ,ijr nraa NtzLk. ,eepiyffhd mstlil rpWk jpirkhww epiyffhd mstlilf nfhLfFk.

jwNghJ Kgglllfjij effptpIL› ,izahffpaypUeJ tUk gpkgjij Neubahf njhiyNehffpapd topNa ghhfFk tifapy njhiyNehffpiar Rowrp mstLfisf FwpjJfnfhss NtzLk ,ttpuzL mstLfspd NtWghL rpWkjpirkhwwf Nfhzjijf (D) nfhLfFk. Kgglllfk nraagglI nghUspd xsptpyfy vzizg gpdtUk rkdghlbidg gadgLjjpf fzffplyhk.

$$m = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

ntwwpl Kgglllfk xdwpDs jputjij epugggp› Nkw$wgglI mNj Kiwapy Nrhjidfis epfojjp jputjjpd xsptpyfy vzizf fhzyhk.

kdpj tpop (The eye)

kdpj caphfSfF ,awifahf mikag ngww xspapay fUtp tpopfshFk. tpopnydR RUqfp tpiwAk jdikia ngwwpUggjhy tpopnydrpd FtpajJ}ujij xU Fwpgggpll mstpwF tpopapdhy khwwpaikff ,aYk. tpopfs KO jshT epiyapy csshNghJ› mtwwpd FtpajJ}uk ngUkkhFk. tpopfisr RUffpg nghUsfisg ghhfFk NghJ› mtwwpd FtpajJ}uk rpWkkhFk. njspthfg nghUsfisf fhz› nghUspd gpkgk tpojjpiuapd kJ (retina) rhpahf tpoNtzLk. taJ tej xUthpd tpoapd tpllk fplljjll 2.5 cm. mjhtJ› tpopnydRfFk› tpojjpiufFk ,ilNa css J}uk vgNghJk 2.5 cm MFk. tpoapy css ,uzL xspGFk jputqfshd mfFt] jputk kwWk tpIu] jputk Nghdwtwwpd xsptpyfy vzfisf fUjjpy nfhsshky› tpopapd xspapay nrayghlilg gwwp ,qF ehk gbffyhk. rhjhuz ghhit nfhzl xUtuhy› <hpyyhj njhiytpy itffgglLss nghUisg ngUkf FtpajJ}ujJld f_{max} rpukkpdwp tpopapd %yk fhz ,aYk. ,Nj NghdW 25 cm njhiytpy itffgglLss nghUisr rpWkf FtpajJ}ujJld f_{min} tpopapidr RUffpf fhz ,aYk.

kdpjtpopapd ngUkf FtpajJ}uk f_{max} kwWk rpWkf FtpajJ}ujjpwfhd (f_{min}) rkdghlil gpdtUkhW tUtpffyhk. nyd] rkdghlbypUeJ›

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

nghUs <hpyyhj njhiytpy cssNghJ› $u = -\infty$ kwWk $v = 2.5\ cm$ (tpopnydRfFk tpojjpiufFk ,ilNa css J}uk)› ngUkf FtpajJ}ujJld (f_{max}) rpukkpdwp tpopapdhy nghUisf fhZk epiyapy

$$\frac{1}{f_{\min}} = \frac{1}{2.5cm} - \frac{1}{-\infty}$$

$f_{max} = 2.5\ cm$

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$$

nghUs mzikg Gssapy cssNghJ› *u = -25 cm*, kwWk *v = 2.5 cm*. rWkf FtajJ}ujJld toaidr Ruff nghUisf fhZk eiyay.

$$\frac{1}{f_{\min}}=\frac{1}{2.5cm}-\frac{1}{-25cm}$$

$f_{max} – f_{min}$ = 0.23 cm ,ej rwa msT tonydrd FtajJ}ujij khwWtjd %yk <hyyhj njhiytpy eJ mzik eiygGsstiu nghUsfis ekkhy fhz KbfwJ. jwNghJ› ehk ghhitay VwgLk ry nghJthd FiwghLfisg gwwg gbffyhk.

fllgghhit (myopia):

fllgghhit Fiwghlbdhy ghjffggll eghdhy njhiytpy css nghUisj njsthff fhz ,ayhJ. ,fFiwghlbwfhd fhuzk tonydrd FtajJ}uk kfTk FiweJtLtjhFk myyJ tof Nfhsjjd tllk ,ayG eiyiatl mjfkhf ,UggjhFk. ,ttif Fiwghlbdhy ghjffggll eghfsdhy mthfsd fzfisj NjitfF mjfkhf jshtilar nraa ,ayhJ. Mdhy nydRfisg gadgLjj ,fFiwghlbidr rhnraa KbAk.

njhiytpy css nghUsyUeJ tUk ,izfjhfs› tojjiuia milAk KdNg FtffggLfdwd. Mdhy mUNf css nghUsfis ,thfshy edF fhz KbAk. fllgghhit FiwghLila eguhy ghhffggLk ngUkj J}uk x vdf. rh nraAk nydirf nfhzL <hyyhj njhiytpy css nghUsd khagkgjij x Gssapy VwgLjj ,fFiwghlilr rhnraayhk.

nyd] nfhzL fllgghhit Fiwghlilr rhnraAk nydrd FtajJ}ujijf fzffLyhk.

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$$

,qF› ,kkjgGfis nyd] rkdghlby gujaLkNghJ›

$$\frac{1}{f}=\frac{1}{-x}-\frac{1}{-¥}$$

rh nraAk nydrd FtajJ}uk›

nydirf nfhzL <hyyhj njhiytpy css nghUsd khagkgjij x Gssapy ,qF *u = -∞, v = -x*, ,kkjgGfis nyd] rkdghlby gujaLk NghJ›

$$\frac{1}{f}=\frac{1}{-x}-\frac{1}{-¥}$$

rh nraAk nydrd FtajJ}uk›

$$f = -x$$

Nkwfzl rkdghlbYss vjhFwahdJ› gadgLjJk nyd] xU FonydR vdgijf fhlLfwJ. mbggilay ,izfjhfis› ,ejf FonydR thfjhfshf khww ,ejf FonydR thfjhfshf khww tojjiuay Ftakilar nrafwJ.

J}ugghhit (Hypermetropia)

J}ugghhit FiwghLila eghdhy tofF mUNf css nghUsfisj njsthff fhz ,ayhJ. J}ug ghhit FiwghLila eghfsd tonyd] ,ayigtl nkyyajhff fhzggLk. ,jd fhuzkhf tonydrd FtajJ}uk kf mjfkhf ,UfFk myyJ ,ayigtl tofNfhsk RUqf tLtjdhYk ,fFiwghL VwgLk.

,fFiwghLila eghfs;d njs;TW fhlr;a;d krr;W njhiyT (Least Distance for clear vision) 25 cm t;l mj;fkhf ,UfFk. vdNt gbggJ kwWk r;wa nghUsfisf ifa;y vLjJg ghhggJ ,thfSfF r;ukkhfa;UfFk Fw;gghf› taJ %gg;d fhuzkhf VwgLk ,ttif J}ugghhitfF ntsnsOjJ (Presbyopia) vdW ngah. tajhdthfshy t;o;iar RUff; t;o;nydr;d Ft;ajJ}ujij Fiwff ,ayhJ.

mzikg Gss;a;Yss nghUs;y;UeJ tUk xs;ffj;hfs to;jj;iufF g;dGwkhff Ft;aiktJ fhllgglLssJ. Mdhy› ,fFiwghLila eghfs;dhy 25 cm fFk mj;fkhd J}ujj;y css nghUsfisjjhd fhz ,aYk. J}ugghhit FiwghLila egh;d t;o;a;y;UeJ ehk fUJk Gss;a;d Fiwejglrj J}ujij y vdf. ,jJ}ujj;wF mgghy css nghUsfis klLNk ,fFiwghLila egh;dhy ghhff KbAk. ,fFiwghlbidr rh;nraa 25 cm J}ujj;y (mzikg Gss;a;y) css nghUisg ghhgjwF 25cm J}ujlj;y css nghUs;d khag;kgjijr rh;nraAk nydr;d cjt;ahy t;o;a;y;UeJ y J}ujj;y NjhwWt;ff NtzLk.

nydR rkdghlilf nfhzL J}ugghhit Fiwghlilr rh;nraAk nydr;d Ft;ajJ}ujijf fzff;lyhk.

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$$

,qF› $u = -25\,cm, v = -y$. ,kkj;gGfis nyd] rkdghlby g;uj;a;Lk NghJ›

$$\frac{1}{f}=\frac{1}{-y}-\frac{1}{-25cm}$$

Nkwfzl rkdghlilr RUff;dhy›

$$\frac{1}{f}=\frac{1}{25cm}-\frac{1}{y}=\frac{y-25cm}{y\acute{}\,25cm}$$

$$f=\frac{y\acute{}\,25cm}{y-25cm}$$

Nkwfzl rkdghlbidf nfhzL fzff;lggLk Ft;ajJ}uk vgNghJk NehFw; kj;gigg ngww;UfFk. Vndd;y› *y* vgNghJk *25cm* l t;l mj;fkhf ,UfFk. Ft;ajJ}ujj;y css NehFw; gadgLjjggLk rh;nraAk nydR Ft;nydR vdgijf fhlLf;wJ. mbggila;y ,ejf Ft;nydR *y* njhiyt;wF mgghy css nghUs;y;UeJ tUk xs;ffj;hfis rwNw Ft;ar nraJ t;o;jj;iua;y Ft;akilar nraf;wJ.

xUjsg;ghh;it (Astigmatism)

t;o;nydr;y› nttNtW tisT Muqfisgngww jsqfs fhzggLtjhy xUjsgghhitf FiwghL VwgLf;wJ. xUjsgghhit FiwghLila egh;dhy midjJj j;irfs;Yk njs;thf xdWNghy ghhff ,ayhJ. f;llgghhit kwWk J}ugghhit Fiwghlilt;l ,fFiwghL rwNw r;ffyhdjhFk. nttNtW tisT Muqfisf nfhzl jsqfis cila nydRfisg gadgLjj; xUjsgghhit Fiwghlilr rh;nraa ,aYk. nttNtW tisT MuqfisAila jsqfisf nfhzl nydRfSfF cUistbt nydRfs vdW ngah. taJ Kgg;d fhuzkhf xdWfF Nkwgll ghhitf FiwghLfs kd;jhfSfF Vwglyhk. f;llgghhit kwWk J}ugghhit Mf;a ,uzL FiwghLfSk nfhzl kd;jUfF› gbggjwF Ft;fFk fzzhbiaAk› njhiyt;y css nghUsfisf fhzgjwF t;hfFk fzzhbiaAk gadgLjj NtzLk. ,ttW jd;jjd;ahf fzzhbfisg gadgLjJtJ r;ukkhFk. ,jid efFtjwfhf› ,ulil Ft;ajJ}uk nfhzl nydRfSk (bifocal lens), njhlh Ft;ajJ}uk nfhzl nydRfSk (Progressive lens) gadgLf;dwd.